

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

VOL. 29

FEBRUARY, 1937

No. 2

CONTENTS

Observations in the Toronto Filtration Laboratories during the Past Twenty-five Years. By N. J. Howard.....	173
Safe Handling of Chlorine and Ammonia in Water Works Plants. By H. H. Gerstein.....	188
Experiments with Sub-Surface Filters at Toledo. By R. W. Furman.....	194
How Much Water Do We Use? How Much Do We Pay for It? By Charles N. Capen, Jr.....	201
Rates Charged for Industrial Water in Ohio. By Philip Burgess.....	213
The New Atlantic City Pipe Line. By S. N. Williams..	222
Deterioration of Pipe and Its Prevention. By William R. Conard.....	231
Protection of Distribution Systems by Water Correction. By H. S. Hutton.....	234
Water Works Systems for Federal Projects. By E. W. Becker.....	240
Pension Systems Based on Insurance. By Merrill Taft.	246
Water Works Finance and Accounting Practice. By Jacob Schwartz.....	251
Diesel Engines in Water Works Practice. By W. E. Wechter.....	259
Diesel Engines at Freehold, N. J. By W. J. Schiverea..	270
New Publications.....	274
Abstracts.....	279
Coming Meetings.....	v
Additions to Membership List.....	vi
News of the Field.....	1

SECRETARY'S OFFICE, 29 WEST 39TH STREET, NEW YORK

All correspondence relating to the publication of papers should be addressed to Harry E. Jordan, Secretary, American Water Works Association, 29 West 39th Street, New York.

Because of the necessity for rigid economy, no reprints of articles will be furnished to contributors free of charge. Reprints may be purchased at the usual prices.

Subscription Price, \$7.00 per annum

Single copies, to members—50 cents, to non-members—75 cents

SAVING TOMORROW'S TAX DOLLAR

A representative page from the W & T Accounting Department records showing actual maintenance costs on a Visible Vacuum Chlorinator.

THE CHLORINATION DOLLAR MUST BUY..MAINTENANCE ECONOMY

"HOW MUCH does it cost for upkeep?" is tomorrow's question. With a W & T Visible Vacuum Chlorinator the answer is ready—"Annual maintenance less than ONE PERCENT of the purchase price."

Analysis of repair costs of over 4,000 installations reports this figure. The reason—Visible Vacuum design,—every working part in plain view under the glass bell jar. No hidden springs or diaphragms to fail, no small parts or orifices to clog, no interruption of Chlorination's vital task.

Ease your mind on chlorination by selecting W & T Visible Vacuum Chlorinators for dependable, accurate, trouble-free service, at minimum maintenance expense.

Through years of service tomorrow's taxpayers will applaud your choice of low maintenance equipment.

Technical publications 38, 157 and 158 describe W & T Visible Vacuum Chlorinators. Ask for your copies.

WALLACE & TIERNAN CO. Inc.
Manufacturers of Chlorine and Ammonia Control Apparatus
NEWARK, NEW JERSEY • BRANCHES IN PRINCIPAL CITIES



THE ONLY SAFE WATER IS A STERILIZED WATER

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings.
Discussion of all papers is invited

Vol. 29

FEBRUARY, 1937

No. 2

OBSERVATIONS IN THE TORONTO FILTRATION LABORATORIES DURING THE PAST 25 YEARS

By N. J. HOWARD

(Director of Water Purification, Toronto, Ontario)

INTRODUCTION

Since the establishment of the Toronto Filtration Plant Laboratories in 1911, a time when none of the city water supply was filtered and chlorination had just been started, much work of practical value has been done. The normal function of a water laboratory is to control scientifically the chemical application and plant operation, to check up filter efficiency, to make chemical analysis of any material or substance met with in practice, to carry out research work which is likely to improve both chemical and bacteriological laboratory technique, in addition to improving plant operation with a possible reduction of maintenance costs. Laboratories were originally equipped for routine examination of water, but the scientific control of water has advanced rapidly in recent years. It is necessary to keep apace with the times and gradually install equipment to study the many problems associated with the chemical theory of precipitation and coagulation, questions associated with sterilization treatment of water, the growth of algae and bacteriological researches. As in all other branches of science, the most productive results have been shown to be the direct outcome of research and experimental work.

The extensive nature of the work carried out in the Toronto Laboratories can best be indicated by the great increase in the total number of yearly examinations made. In 1912, when the systematic examination of raw and filtered water began, 8,096 tests were carried out; this figure in 1935 rose to 35,403. The laboratory work includes routine chemical, bacteriological and microscopical examination of the raw, filtered and chlorinated water, examination of well supplies, sewage and ice samples, boiler incrustants and compounds, analysis of alum and other water supply chemicals, experimental work on the corrosive action of water, chlorine and alum on various metals, the sterilization of water by chlorine and other oxidising reagents, the causes of taste formation in water and methods of correction, and a considerable amount of bacteriological research, chiefly associated with isolation of the colon-aerogenes group of bacteria.

The purpose of this paper is to state briefly, from a laboratory viewpoint, observations recorded between the years 1911 and 1935, covering a period of some twenty-five years. A considerable amount of this work has already been published in detailed form, but a presentation of some of the work at this time, may help to refresh our minds and furnish some discussion of interest.

PROBLEMS ASSOCIATED WITH MICROSCOPIC ORGANISMS

In considering problems associated with filtration, studies have been made on the seasonal visitation of algae and their effects on both slow sand and drifting sand plants, the winter and summer concentrations of bacteria and their effect on filtration efficiency, the copper sulphate treatment of influent water feeding the slow sand filters and the prechlorination of mechanically filtered water. Exhaustive researches were also carried out to determine the bacteriological efficiency resulting from the use of fine and coarse grades of sand. The great increase of algae in Lake Ontario in the early spring months, usually May and June, has an adverse effect on the slow sand plant, cutting down the filter runs from seven to two or three days, necessitating intensive sand raking and cleaning during these periods. Trouble has been chiefly associated with *Asterionella* occurring in concentrations as high as 1928 standard units per cubic centimetre. It is of interest to note that plankton life appears to develop and thrive in shallow and on-shore water, the spring trouble usually occurring during periods of easterly winds which cause the

shore water to be carried out over the intakes. With a change in wind, the excessive microscopic life suddenly disappears, conditions becoming normal again. During the warm water months, while the plankton life greatly increases, abnormal changes in the microscopic content of the water do not occur, neither are the slow sand filters appreciably affected. Microscopic life does not affect the operation of the drifting sand plant, the loss of head showing no change. This is doubtless due to the continuous cleaning process, which is a normal function of this system. The suggestion was made some years ago, to try the effect of copper sulphate on the raw water for prolonging slow sand filter runs. This was against the writer's advice, based upon the deduction that, without adequate storage, copper sulphate could only kill off the organisms in the water entering the filters, and that the organisms whether living or dead would probably have the same clogging effect. After a months' trial run the treatment was abandoned without improvement in loss of head and no effect on length of filter runs. When the filter was taken out for cleaning, rapid decomposition took place, the surface film smelling offensively. For several days after cleaning the bacterial count showed high figures, indicating that decomposition had also occurred within the sand medium, destroying the natural biological action which normally takes place in slow sand filtration.

SEASONAL VARIATIONS IN EFFICIENCY

On a large plant such as Toronto possesses, which includes two entirely different systems of treatment, the seasonal differences in purification are of absorbing interest. The greatest bacterial concentration in Lake Ontario occurs in the summer and early fall months, when the water temperature is the highest. This is the reverse of conditions reported by other observers, who in some cases have recorded the highest bacterial figures during the winter months, possibly due to rain or flood conditions. Some years ago, Wells noted that the number of *B. coli* present in human feces increased enormously as the temperature rose, reaching its maximum in the month of August. He stated that, "The remarkable degree to which three independent curves are parallel cannot be attributed to mere chance. It must be admitted that the seasonal distribution of *B. coli* is related to the seasonal variation of *B. coli* within the intestine." The figures show that during many years past in Toronto, the total number of bacteria and the *B. coli* content of the raw water follows

the same curve as indicated by Wells. During a period of years the indicated number of *B. coli* per cubic centimeter, showed an average figure of 7.42 in the month of February as against 54.34, 662.09 and 2126.13 in the months of June, July and August, respectively. In Toronto the highest degree of bacterial removal occurs in the slow sand plant during the summer months and in the mechanical plant during the winter months. In other words, as the bacterial pollution increases and the water warms up, the efficiency of the slow sand plant improves and is maintained; inversely the quality of the mechanical plant effluent is reduced. It should be pointed out, however, if increased amounts of alum are applied, higher efficiencies can be maintained in the mechanical plant. The application of large doses of alum to a raw water having a turbidity of less than 2 parts per million, in order to secure high bacterial removal, is somewhat questionable, when it is borne in mind that the effluent is always sterilized by chlorination. As reported at other plants, *B. coli* appears to pass more frequently through rapid sand filters than do other types of bacteria, the total number of bacteria growing on agar at 37°C., being always proportionately less. Quite often counts on agar are under 10 per cubic centimeter while the *B. coli* test for the same amount will give a positive result. It may be that the liquid media is more sensitive than the solid medium. The seasonal variation in bacterial efficiency is readily understandable in slow sand filters, but is somewhat obscure in rapid sand filtration. In 1921, Wolman and Hannan suggested that the conditions were controlled by the hydrogen-ion concentration and the temperature of the water. About the same time Jordan pointed out that filtration taken as a whole falls off in effectiveness as the temperature rises, a phenomenon which he associated with biological activity. To the writer it seems likely that problems frequently encountered in rapid sand filtration are largely controlled by local conditions, and may be more influenced by colloidal properties than by the pH concentration. Granted that physical and colloidal chemistry are very closely allied, and also granted that the pH does actually control the situation in certain types of water, when dealing with a water similar in character to Lake Ontario, the solution to coagulation and resultant purification questions rests more in the field of colloids than in a study of the H-ion concentration of the water. This opinion is based upon the fact that the hydrogen-ion concentration of the water is approximately 8 in the winter months and 8.0 to 8.4 in the summer months,

and there is no definite indication that this small variation in the hydroxyl ions is sufficient to account for the marked seasonal variation in filter efficiency. On the other hand, the bacterial concentration is the highest during the months that difficulties are experienced in maintaining the bacterial efficiency of the drifting sand plant, and it is an established fact that this pollution is due to sewage of recent origin. The differences in the colloidal content of sewage under warm and cold weather conditions are well known and it seems reasonable to assume that the organic content of the raw water also varies from day to day. In addition to the organic content, similar changes occur in the organic colloids, and these by virtue of their varying degree of absorption, might have much to do with the seasonal changes noted. The organic colloids found in sewage carry negative charges and are highly complex and unstable. When the biological content of the raw water is high, it is apparent that the presence of enormous numbers of negatively charged colloidal molecules would require an increased quantity of alum, which is said to be positively charged, if an effluent of bacterial purity is to be attained. An excess of alum would increase the positive charges present and tend to re-establish electrical equilibrium. The cause of seasonal variations in the efficiency of plants is still a matter of conjecture, and doubtless when the study of physical and colloidal chemistry has further advanced a more basic solution will be forthcoming. The suggestion at the present time that waters in general, can be definitely treated on a pH or colloidal basis would seem to be doubtful.

Some interesting observations were carried out in the sand studies previously referred to. It was our opinion that a finer grade of sand in rapid sand filters would produce a proportionately higher bacterial removal. Figures showed that very little change resulted in the use of filter sand having a size ranging between 0.3 and 0.56 mm. The effect on loss of head was of course appreciable, while at higher rates, turbidity passed through the coarser sand at a slightly increased rate. The effect on loss of head was proportional to the size of sand.

BACTERIOLOGICAL OBSERVATIONS

The use of gelatine plates at 20°C., was discontinued several years ago, chiefly on account of the enormous growth of psychrophillic organisms which developed during the winter months, resulting in counts in excess of 250,000 per cubic centimeter, and which were of no sanitary significance. With these high counts, *B. coli* was oc-

casionally absent in 100 cc. These organisms were studied in the laboratory by J. Race, who found that they would not grow at a temperature in excess of 27°C. A study of the bacteriological figures during the past twenty-five years has shown a progressive increase in pollution following the normal industrial development and increase in population in the various municipalities within a reasonable distance of Toronto. A survey completed in 1921 showed a pollution along the lake front for a distance of approximately 16 miles extending out into the lake for several miles. It is not suggested that this situation only applies to Lake Ontario, it being a common condition throughout the American continent, in spite of the many state and provincial laws prohibiting the pollution of navigable waters. No immediate solution would seem to be in sight due in part to the financial stringency, the expressed desire of municipalities to withhold the spending of large sums of money on sewage disposal and the lack of enforcement of existing legislation.

STUDIES ON THE COLI-AEROGENES GROUP

Much work has been undertaken in connection with the test for the isolation of the colon-aerogenes group. These studies included the use of lactose broth according to standard practice, involving presumptive positive tests (many of which are not confirmed), the use of lactose broth plus the addition of inhibitory salts and triphenylmethane dyes, the introduction of buffer salts in the presumptive media for the reduction of lethal acidity and the use of solid media for the differentiation of fecal and non-fecal types. These studies were largely undertaken in 1925 and clearly indicated the limitations of lactose broth, although this medium did actually produce the largest final number of confirmed positive tubes. At this time in dealing with brilliant green bile broth, we found that brilliant green lactose broth alone was highly inhibitory and useless except to restrict the growth of the colon group and that there was little difference between certain kinds of bile used in conjunction with lactose broth for the presumptive test, a slight inhibition being noted in all. Brilliant green bile salt broth produced slightly less presumptive positive tubes but 96 percent of all positives confirmed. It was however found that the use of brilliant green bile broth as a confirmatory medium was a rapid and reliable method of partially confirming the colon group, a practice which was later adopted in Toronto.

Further studies were made by Thompson in 1927, who pointed out that while it is generally known that *B. coli* is inhibited by the formation of acidity in carbohydrate-containing media, this does not seem to have been seriously considered as a factor in the failure of presumptive tests to confirm, and further that the production of a lethal H-ion concentration may be largely eliminated by increasing the buffering of the presumptive medium by means of the addition of dipotassium phosphate. Buffering increases the bacterial growth rates and also the amount of gas produced both in lactose broth and in brilliant green bile broth. Our work was not very productive in the use of direct planting on a solid medium for differentiation of the fecal and non-fecal types, possibly due to imperfect preparation of the Noble medium which has since been greatly improved. It seems that considerable first hand experience is necessary for differentiation of typical and non-typical colonies. An exhaustive study was made of eosin methylene blue agar, and in addition to the five types of colonies originally described by Levine as growing on this medium, some eight other colonies were studied. We found that some of the latter colonies produced a characteristic sheen formation which clearly did not belong to the colon group. Another point of interest was that out of 967 colonies classified as belonging to the colon group, 84 (8.7 percent) definitely failed to ferment lactose on subculture. There were also some 12 colonies isolated which failed to ferment any of the six groupings of carbohydrates used in the study regardless of the fact that the organisms were typical in character and grew well in Endo's medium and MacConkey's bile salt agar. The summarised results showed that out of 1233 colonies isolated, 82 percent fermented lactose. Of these 967 were classified as belonging to the colon group, of which 91.3 percent fermented lactose. The aerogenes group consisted of 85 colonies, of which 93 percent fermented lactose. Of 181 colonies non-typical in character 27.1 percent fermented lactose. In the colon group 53 percent fermented dulcitol while 47 percent were negative; in the aerogenes group 43.5 percent were positive to dulcitol and 56.5 percent negative. The classification of colonies growing on eosin methylene blue agar, based upon their sugar reactions, is somewhat uncertain. It is essential to subculture all colonies isolated if reliable results are desired. The medium still remains one of the most useful in general use, but our work indicated that definite classification of the colon-aerogenes group based on a positive or negative dulcitol reaction upon subculture is unreliable.

CHEMICAL RESEARCH

The increase in chlorides from 7.7 in 1911 to 13.5 in 1935 gives some indication of the great increase in pollution of the raw water. The chemical figures closely parallel the bacteriological results. The *B. coli* index which in 1912 was 0.496 per cubic centimeter, rose in 1920 to an all-time high figure of 1535.51. During the past few years while the pollution has been heavy, the *B. coli* index rarely reached the last-named figure.

One study to which comparatively little attention has been given is that of residual alum in the effluents of rapid sand plants. So far as the writer knows, the question was first raised at the 37th Annual Convention of the New England Water Works Association, following the presentation of a Toronto paper on the drifting sand filtration system. At that time the position was taken by several well known sanitarians that the passage of alum in any form whatever pointed to a defect in the filtration system involved. In Toronto, laboratory experiments first demonstrated that in a filtered water of similar chemical content, sedimentation did not appreciably reduce the amount of residual alum, the same results being obtained in the filtered water after 4 minutes and 4 hours sedimentation. Similar experiments were made with a colored water containing 30 p.p.m. of color and 50 parts of alkalinity. It was found that the color was reduced by filtration using 2.25 grains per gallon of alum after a contact period of 5 minutes. This latter experiment was undertaken to secure comparative information on the removal of color, special references to the question of a definite period of sedimentation being necessary. It is not suggested that all colored waters could be effectively treated with a short period of sedimentation. The whole problem would seem dependent upon the hydrogen-ion concentration, the nature of the color and the colloidal content of the water involved. As regards the residual alum experiments, we were unable to find a water which, after treatment with alumina sulphate with subsequent filtration, did not contain colloidal alumina. A summary of observations reported was as follows: (1) effluents from all treated waters examined gave positive reactions; (2) raw water from Lake Ontario and Lake Erie gave negative results; (3) intensity of positive reaction slowly diminished on long standing, but after 6 months was still perceptible; (4) freezing did not affect the reaction, neither did boiling; (5) filtered through 6 thicknesses of Whatman's No. 5 filter paper, the reaction was still obtained, there being evidence of ad-

sorption of sol by the paper; (6) the sol freely ascended bibulous paper—over 13 cm. in 48 hours; (7) water of pH 8.0 to 8.6 yielding no reaction, if brought into contact with alumina gels or if passed through a filter paper which had adsorbed alumina sols, will yield positive reaction; (8) non-reacting Al in solution (normally present in Lake Ontario) can be made to react by slightly acidifying, boiling, cooling and restoring the original pH value by cautious addition of ammonium carbonate. The presence of iron may interfere with this test as haematoxylin combines with iron in preference to alumina when both are present together in reactive form. These reactions can be accounted for if we assume; (a) haematoxylin enters into reaction with alumina sols but not with aluminate ion; (b) alumina gel is readily peptised in presence of OH-ion, even at pH 8.0; (c) alumina sols are not stable in presence of OH-ion but are converted into aluminate ions; (d) aluminate ions are stable in presence of OH-ion, but are decomposed by acids with formation of aluminum ions. (e) the degree of dispersion of the sols is probably greater: (1) with increased OH-ion concentration or (2) after severe filtration; (f) higher dispersion accelerates the course of reactions. In Toronto we were able to demonstrate that the residual alum after filtration was a hydrate in colloidal form, which subsequently became an aluminate, the exact nature of which has not been determined. We found that the residual alum in the effluent was in colloidal form having no corrosive properties, did not produce any after-precipitation and showed no evidence of protecting bacteria against the sterilizing effect of chlorine. In plain language it can be said to be of no sanitary significance.

Other subjects connected with physical and colloidal chemistry included studies of hydrogen-ion concentration, water supply problems, and microforces, with reference more especially to orientation and curvature. In 1922, Hannan pointed out that probably the most fruitful application of hydrogen-ion control to water filtration will be found in wise wielding of the power placed in our hands to vary the electrical charges on particles of all kinds in the water, from the finest colloid dispersion to the coarsest sand, rendering them, to an extent which even yet seems little realized, more amenable to effective treatment. The second subject included a discussion of the character of forces affecting coagulation and filtration and the probable influence of forces of "low potential energy" only capable of acting on masses of practically molecular dimensions. In this ab-

sorbingly interesting study it was concluded that: (1) peripheral layers of quiescent water are identical in all their physical properties with the bulk; (2) orientation is offered as being, in the present state of our knowledge, the most probable explanation; (3) differentiation is a rapid process (In diffused light, at ordinary temperatures, the Liebreich zone is discernible within 5 to 10 minutes); (4) tangential spreading of the differentiated layers over fresh surfaces adjoining occurs actively; (5) the effective curvature at an interface is not always inappreciable; (6) the principle of equilibrium interfacial curvature is suggested; (7) attention is directed to interfacial systems and to their intersections.

RESEARCH ON CHLORINATION

Possibly more work of a research nature has been carried out in the Toronto Laboratory in connection with chlorination problems than on any other topic. Since sterilization treatment was commenced in 1911, in the midst of a typhoid fever epidemic, the question of taste and odor in the water supply has been a major issue, and for a period of 10 years intensive research studies were made. The first attempts at finding a definite solution to taste causation and prevention was in 1921, when chlorine-ammonia and excess chlorine were tried out on a laboratory scale. In 1922, the writer presented a paper at the Philadelphia meeting of the American Water Works Association which included the first detailed figures on the amounts of phenol in water which were capable of causing taste in chlorinated water. At this time superchlorination treatment was suggested as the most effective process then known. Experiments made with ammonia were ineffective in Toronto for two reasons. First the water was so heavily polluted with trade wastes and organic matter that the treatment was of little help. In some instances the taste was intensified and at no time was the water rendered free from taste. The other reason was that after two hours' contact, positive tests were still being recorded in the B. coli test in 1 cc. or less. The effectiveness and germicidal value of chloramine treatment should always be tested before being adopted. With only moderate pollution and sufficient time for sterilization, successful treatment has been well demonstrated, possibly no better example being available than in the City of Cleveland. Between the years of 1922 and 1935 a great deal of work was carried out in Toronto, and in 1926 a paper was read before the New England Water Works Association dealing with

the causes of taste and odor and methods of treatment adopted in Toronto. This paper dealt largely with tastes and odors occurring in chlorinated water chiefly caused by organic matter and trade wastes, and reference was made to the studies of Donaldson, Willcomb, and Waring. In the laboratory work, a special study was made of some 28 substances derived from the products of the destructive distillation of coal. In water containing 0.25 parts per million of chlorine we were able to show that the taste forming substances were practically confined to the monosubstitution groups. Phenol, ortho-, meta- and para-cresol, xylenol, and anisol caused the characteristic chemical or "iodoformish" taste in water. Of the cresol group, which produced marked odor as well as taste, ortho cresol produced a more pronounced taste than meta cresol. The para-cresol caused a foul iodoform odor but the taste was much less pronounced than with either of the other two and was easier to destroy by excess chlorine. Xylenol caused a very strong iodoform taste and odor while anisol caused both taste and odor. Thymol retained its characteristic properties which were not affected by small doses of chlorine but were broken down by large doses. Guaiacol caused a decided chemical taste and odor which is distinctive from that produced by phenol or cresol. When using the Folin-Dennis reagent for estimating phenol and cresol we were not able to distinguish between either grouping beyond a slight difference in the intensity of color. Summarising our work at this time we found that: (1) at Toronto, while phenol is contributory to the production of taste, there are other causes of unknown origin; (2) in many instances, taste is directly attributable to the production of substitution compounds formed in chlorinated water by the phenol and cresol groups; (3) decomposing organic matter may form phenolic bodies and cause taste in chlorinated water; (4) of a large group of substances examined derived from the destructive distillation of coal, phenol, cresol, anisol and xylenol will produce an iodoform taste or odor in the presence of free chlorine; (5) thymol and guaiacol in chlorinated water retain certain chemical characteristics but do not produce the iodoform taste or odor (These tastes can be broken down by excessive doses of chlorine); (6) the colorimetric test using the Folin-Dennis reagent as a means of identifying taste-producing substances, is of limited value; (7) the formation of chloro-phenol substitution compounds in chlorinated water can be prevented by the excess chlorine and dechlorination method; (8) definite time contact periods

are necessary for varying doses of taste-producing substances to effect their destruction; (9) the contact period can be shortened by greatly increasing the chlorine dosage; (10) a definite excess of sulphur dioxide is necessary to remove all traces of residual chlorine; (12) technical supervision is essential for effective and economical operation of the super- and dechlorination treatment; (13) taste may be influenced by the hydrogen-ion concentration of the water. Acid and highly alkaline water are the least liable to taste.

At this time an observation of some interest and importance was made. It has reference to the effect of sunlight on color production in chlorinated water following the introduction of ortho-tolidin, and demonstrated that color tests should always be made in the absence of sunlight or the sample should be protected from the sun's rays while the test is being made. The average difference of 16 tests made, showed that when the sample was protected from sunlight the residual chlorine averaged 0.134 while a duplicate series of samples after exposure to sunlight gave an average residual of only 0.043 part per million. The interference in color production is directly proportional to the intensity of sunlight. We demonstrated that the effect is due to interference with color production and not increased rate of chlorine absorption by water in sunlight. This was proven by allowing chlorinated water to stand in sunlight for 5 minutes and then adding the ortho-tolidin solution. Practically no change occurred in the residual chlorine.

Some brief observations were also made to determine whether large doses of chlorine would affect the hydrogen-ion concentration of water. We found that when 3.0 parts per million of chlorine was applied to a hard or soft water supply, the reaction was practically unchanged. In the case of the soft water, which had a hardness of approximately 50 parts and a color of 60 parts per million, the pH was reduced from 7.1 to 7.0, but the color was reduced considerably, showing the effect of chlorine upon certain types of color normally occurring in water.

The re-introduction of prechlorination in 1921 in Toronto on a large scale, was partly instrumental in the more extended use of this treatment throughout the American Continent. Prior to this year there were about three cities in the United States using prechlorination for various purposes. The writer, when visiting England at this time, found that the late Sir Alexander Houston had adopted prechlorination on part of the London water supply. This was ef-

fectured during the Great War in lieu of storage. It should be mentioned that part of the Thames River supply was stored in huge reservoirs for several weeks prior to passage through slow sand filters. By prechlorinating instead of storing, a large economy was effected, the saving resulting from the fact that the water had to be pumped into the reservoirs. The net result was a bacteriologically safer water and with prechlorination treatment, the water was allowed to go direct to the filters. By the time the water reached the filters no residual chlorine remained. At this time in Toronto, the mechanically filtered water was being treated with alum doses ranging between 0.5 and 2.5 grains per gallon, involving a total consumption of 1,200 tons per year. The adoption of prechlorination in Toronto was at the time somewhat severely criticised, it being claimed that the chlorine destroyed the filtering film and the gelatinous coating of the sand grains. It is possible that there was some theoretical basis for this claim, but it should be pointed out that no excessive application was ever made. As an economy measure, the treatment more than justified its use, as during the first year the alum consumption was reduced to less than 300 tons resulting in a net saving in operation of an amount in excess of \$34,000. The saving over a period of 5 years was sufficient to maintain the entire laboratory service for 10 years. The advantages shown to result from prechlorination were: (1) purer water obtained; (2) great economy effected; (3) operation of plant greatly facilitated; (4) an increased rate of filtration from 150 to 175 million gallons was possible during the summer months. In 1922, further modification was made in the prechlorination treatment, whereby the joint use of alum and chlorine resulted in an additional economy being effected. The modified treatment demonstrated that a combination of 0.5 grain of alum and 0.2 to 0.4 part of chlorine, produced a water physically and bacteriologically better than when alum alone in larger doses was applied. Chlorine used is primarily responsible for the bacterial reduction, and may assist clarification when used in conjunction with alum. It is possible that chlorine in some way alters the balance between the electrolytes present.

The foregoing is intended to give a brief idea of some of the work carried out during recent years. Publicity to the city originating researches is always worthwhile. The amount of reduced maintenance costs, the facilitation of operation and the researches leading up to great improvements in the quality and palatability of a water

supply, are examples of the value to a municipality of a well-organised laboratory. If this paper serves to stimulate discussion and brings out points of interest and the troublesome conditions frequently encountered on all purification plants, it will have served its purpose. The writer would be very remiss if he failed to associate with himself, all of the members of the staff who have materially contributed to the successful treatment carried out in Toronto during a period of twenty-five years. Their efforts and coöperation more than anything else have made progress possible.

(Presented before Central States Section, August 19, 1936.)

PAPERS PUBLISHED FROM THE TORONTO FILTRATION PLANT LABORATORIES

- (1) J. RACE. The Treatment of Water with Chlorine. *J. Soc. Chem. Ind.*, 1912.
- (2) GEO. G. NASMITH AND N. J. HOWARD. Test on Drifting Sand Filter. *Canadian Engineer*, October, 1918.
- (3) N. J. HOWARD. Operation of Slow Sand Filters at Toronto. *Canadian Engineer*, September, 1919.
- (4) N. J. HOWARD. Description, Operation, and Purification Effected by Drifting Sand Filtration System in Toronto during 1918. *J. New Eng. Water Works Assocn.*, Vol. 33, No. 4, 1919.
- (5) N. J. HOWARD AND F. HANNAN. Alumina Hydrate in Mechanically Filtered Water. *Canadian Engineer*, May, 1920.
- (6) N. J. HOWARD. Relation of Raw Water to Endemic Typhoid Fever. *Canadian Engineer*, January, 1921.
- (7) N. J. HOWARD. Statistical Record of Toronto Water, 1912-1922. *Canadian Engineer*, May, 1922.
- (8) N. J. HOWARD. Chlorination Prior to Filtration. *J. Am. Water Works Assocn.*, Vol. 9, No. 4, 1922.
- (9) N. J. HOWARD. Modern Practice in Removal of Taste and Odor. *J. Am. Water Works Assocn.*, Vol. 9, No. 5, 1922.
- (10) F. HANNAN. Hydrogen-ion Concentration and Water Supply Problems. *J. Am. Water Works Assocn.*, Vol. 9, No. 1, 1922.
- (11) N. J. HOWARD. Methods of Purifying Public Water Supplies. *Canadian Engineer*, February, 1923.
- (12) F. HANNAN. Microforces with Reference More Especially to Orientation and Curvature. *J. Am. Water Works Assocn.*, Vol. 10, No. 6, 1923.
- (13) N. J. HOWARD. Modified Prechlorination Treatment at Toronto. *Canadian Engineer*, February, 1924.
- (14) N. J. HOWARD AND R. E. THOMPSON. Isolation of the Colon Group in Water. *Canadian Engineer*, April, 1925.
- (15) N. J. HOWARD AND R. E. THOMPSON. Chlorine Studies and Some Observations on Taste Producing Substances in Water, and the Factors Involved in Treatment by the Super- and Dechlorination Method. *J. New Eng. Water Works Assocn.*, Vol. 20, No. 3, 1926.

- (16) N. J. HOWARD AND R. E. THOMPSON. Discussion of Superchlorination Treatment. *J. New Eng. Water Works Assn.*, Vol. 21, No. 1, 1927.
- (17) R. E. THOMPSON. Irregularities in the Test for B. Coli in Water. *J. Bact.*, Vol. 13, No. 3, 1927.
- (18) R. E. THOMPSON. Water Hardness, Its Effects and Removal. *J. Am. Water Works Assn.*, Vol. 20, No. 4, 1928.
- (19) N. J. HOWARD. Modern Aspects of Chlorination of Water. *J. Am. Water Works Assn.*, Vol. 19, No. 5, 1928.
- (20) N. J. HOWARD. The Value of a Water Purification Laboratory to a Municipality. *Contract Record and Engineering Review*, June 19, 1929.
- (21) N. J. HOWARD. The Rapidly Extending Use of Chlorine in Sanitation. *Contract Record and Engineering Review*, March 12, 1930.
- (22) N. J. HOWARD. Progress in Superchlorination Treatment for Taste Prevention at Toronto, Ontario. *J. Am. Water Works Assn.*, Vol. 23, No. 3, March, 1931.
- (23) N. J. HOWARD. Water Analysis, Its Interpretation and Relationship to Water Purification. *J. Am. Water Works Assn.*, Vol. 24, No. 1, 1932.
- (24) N. J. HOWARD. Isolation of the Colon Group in Water. *J. Journal Canadian Public Health Assn.*, February, 1932.
- (25) N. J. HOWARD. Activated Carbon and Its Value in the Removal of Tastes and Odors from Water Supplies. *Contract Record and Engineering Review*, March 9, 1932.
- (26) N. J. HOWARD. The Progressive Fight Against Typhoid Fever in Canada During the Past Twenty Years. *J. Canadian Public Health Assn.*, August, 1932.
- (27) N. J. HOWARD. Comparison of Results with Standard Brilliant Green Bile and Dominick-Lauter Broths. *J. Am. Water Works Assn.*, Vol. 24, No. 9, September, 1932.
- (28) R. E. THOMPSON. Importance and Value of Softening Municipal Water Supplies. *J. Canadian Public Health Assn.*, Vol. 23, No. 11, November, 1932.
- (29) N. J. HOWARD. Chlorine—What It Has Done for Sanitation and Industry in Canada. *Contract Record and Engineering Review*, March 22, 1933.
- (30) N. J. HOWARD AND DR. A. E. BERRY. Algal Nuisances in Surface Waters. *J. Canadian Public Health Assn.*, August, 1933.
- (31) N. J. HOWARD. The Scale Buoy System of Processing Water. *Electrical News and Engineering*, May 15, 1935.
- (32) N. J. HOWARD. The Causes of Tastes and Odors in Water Supply and Methods of Correction. *J. Penn. Water Works Association*, Vol. 7, 1935.
- (33) N. J. HOWARD. Some Causes of Water Quality Deterioration in Distribution Systems. *Canadian Engineer*, Vol. 70, No. 25, June, 1936.

SAFE HANDLING OF CHLORINE AND AMMONIA IN WATER WORKS PLANTS

By H. H. GERSTEIN

(Sanitary Engineer, Department of Public Works, City of Chicago)

The increasing and widespread use of liquid chlorine during the last twenty years in water works plants for disinfection and as an aid to filtration processes, and in the last five years the use of anhydrous ammonia in connection with the ammonia-chlorine process, has created special problems with regard to hazards due to accidental escape of these highly toxic chemicals which should be of special concern to every water works operator. While relatively few accidents from use of chlorine and ammonia have been reported at water works plants, a real potential danger exists wherever these chemicals are used and it should be recognized. Experience has shown that these chemicals can be safely used in water works plants, provided that particular attention is given to proper design of storage and handling equipment and to the thorough training of operators in proper methods of handling.

The subject of safe handling of ammonia and chlorine has been thoroughly covered in recent pamphlets issued by various chemical manufacturers, the National Safety Council and particularly in the recent reports of the committee of the American Water Works Association on control of hazards from use of chemicals in water works plants. It is highly important that every operator in plants using chlorine or ammonia should thoroughly familiarize himself with the contents of these reports in order that he may be able to handle the chemicals intelligently and be prepared to meet almost any reasonable emergency situation.

The material presented in this paper will therefore be confined to a general discussion of the problem, placing emphasis on some "do's" and "don'ts" which, based on experience in Chicago in the use of over 900 tons of chlorine each year at twelve separate chlorinating plants, have been found helpful in reducing hazards; and also to direct attention to the fact that the methods for safe handling of chlorine and ammonia differ for each chemical because of certain differences in their chemical and physical properties.

WORKMEN AFFECTED

A striking example of the potentialities of hazard from use of these chemicals may be found in a recent experience at Chicago where evidence was uncovered that severe headaches and coughing among men working in the basement of one of the pumping stations was probably caused by the presence in the atmosphere of a small amount of phosgene, a deadly war gas, which was carried into the station through a duct connected to a water tunnel shaft in which chlorine solution was being applied. Tests showed the presence in the shaft of chlorine gas and an inflammable gas, the identity of which was not determined. Decreased water coverage over the ends of the chlorine solution hose because of low elevation of the water in the shaft, caused by abnormal flow in the tunnel, allowed the escape of chlorine gas, while the presence of the inflammable gas in the shaft was found to be due to infiltration from surrounding soil. Phosgene, the presence of which was determined by qualitative test in the duct leading from the shaft to the pumping station apparently was formed by the combination of chlorine and carbon monoxide gases. Fortunately the condition was rectified before any damage was done.

Particular precaution should be taken to avoid the mixing of chlorine and ammonia gases before they are applied to the water, or the mixing of concentrated water solutions of these gases, since these chemicals under certain conditions may combine to form nitrogen trichloride which is highly explosive.

Chlorine gas is non-inflammable. On the other hand a mixture of about one part of ammonia gas and five parts of air may be ignited under certain conditions by sparks or high temperatures. The dry gases are not corrosive at ordinary temperatures, but in the presence of moisture, chlorine is very corrosive to most materials and should be handled only in resistant materials such as glass, rubber, silver, tantalum and special alloys. Ammonia in the presence of moisture is especially corrosive to copper and copper bearing alloys.

For the same temperature the pressure in containers holding ammonia is considerably greater than in those holding chlorine. For instance, at 80°F., the pressure in a chlorine container is approximately 100 pounds per square inch, whereas, in an ammonia container at the same temperature it is approximately 140 pounds per square inch. At 100°F., chlorine has a pressure of about 140 pounds per square inch and ammonia approximately 200 pounds per square inch. Containers of the chemicals therefore should be stored in

places protected from direct sunlight and away from heaters, steam pipes or inflammable materials because of the hazard of high temperatures creating excessive pressures in the containers. The fusible plugs in the chlorine containers melt at about 160°F., for that reason the temperature of the room in which the containers are stored should never be allowed to approach anywhere near this point.

IMPORTANT SAFETY MEASURES

In handling gas containers, it is good policy to keep protective caps in place over valves in order to prevent damage to the valves. Rope or wire slings or magnets should never be used in handling containers. It has been found best to handle small containers by means of hand trucks. Where hoisting is required on ton containers, it is advisable to use a specially designed lifting rig recommended by the chlorine manufacturer. Scale platforms should be set flush with the floor, so that cylinders can be rolled on and off the scale without lifting. Cylinders placed upright on a scale should be clamped sturdily in position to prevent swaying or falling.

Experience in Chicago has indicated that gas leakage occurs most often while making or breaking connections and from valves. Therefore, in the design of the latest chlorinating plants for the city pumping stations, an effort has been made to reduce the number of connections and valves. The use of larger chlorine containers and higher capacity chlorinators at the new Cermak pumping station has made possible the reduction of the number of connections and valves to less than one tenth of what would be required had the layout of the older plants been followed where chlorine in 100 pound cylinders was used.

Gas leakages should be stopped as soon as they occur. Small leaks become larger and more difficult to control if not taken care of immediately. The old proverb that "an ounce of prevention is worth a pound of cure" can be very well applied to this point.

It is good policy to locate the chlorine and ammonia equipment in separate rooms away from the main part of the plant. There is considerable advantage in the larger installations in having the chemical containers in a room separate from the feeding equipment. The rooms in which the chemicals and equipment are kept should be provided with an efficient ventilating system capable of furnishing at least one to two air changes per minute. Chlorine gas is about two and one-half times as heavy as air and, therefore, has a tendency to

sink to the floor and accumulate in low places. On the other hand, ammonia is about one-half as heavy as air, therefore, having a tendency to rise and dissipate fairly rapidly. Consequently, the ventilating system for rooms in which chlorine is stored should allow air to be taken into the room at a point near the ceiling and be removed from the lowest point; and conversely for ammonia gas, the air should be taken into the room near the floor and evacuated at a point near the ceiling. A combined system in which air is forced into the room by means of a pressure fan and at the same time removed from the room by a suction fan is very satisfactory for clearing rooms of gas leakage. It has been found advantageous to have the suction fan discharge through a high stack in order to obtain rapid dissipation of the gas fumes.

Where conditions warrant taking unusual precaution against the release of large quantities of chlorine such as at the new chlorinating plant at the Cermak pumping station in Chicago, additional protection may be obtained in case of severe gas leakage from a container—not controllable by other means—by providing a tank containing sufficient caustic soda solution to absorb the entire contents of the container into which the leaking container may be lowered. Since ammonia is highly soluble in water, its gas fumes may be removed from the room by spraying.

USE OF GAS MASKS

Each operator in the plant should be provided with an individual gas mask of a type approved by the United States Bureau of Mines. He should be trained by frequent drills in the use of this mask and should be required to wear it on all occasions when leakage of gas occurs.

It is desired to stress the fact that the type of gas mask canister used for protection against chlorine cannot usually be used for protection against ammonia and vice-versa. The United States Bureau of Mines has approved various types of gas canisters, each type to be used as protection against a particular gas or related gases. Each canister is by standard practice, painted a distinctive color to identify the services for which it is designed. The canister recommended for chlorine use is painted yellow and is filled with an absorbent mixture consisting of activated carbon and soda lime. The container used for protection against ammonia gas is painted green and the absorbent material is silica gel. The red all service canister

may be used for protection against both gases, but for most effective protection it is believed advisable to provide a separate mask and canister for each gas. It is good practice to have the purchase date plainly marked on each canister and to replace with a new canister every six months.

Gas masks should be kept in lockers outside of the rooms in which the chemicals are stored, preferably in compartments having glass doors so that the masks are visible for inspection at all times.

An operator should never go into a room in which there is leakage of gas unless he is wearing a gas mask and unless another operator also provided with a mask stands at the door of the room in order to be of assistance in case of need. An important point to be borne in mind is that while a gas mask protects the wearer against reasonable concentrations of the offending chemical, it will not protect the wearer in an atmosphere in which the oxygen content is lower than that necessary to support life.

Both chlorine and ammonia gases are highly toxic, chlorine probably being the more dangerous of the two. Both gases may be detected by their distinctive odors in concentrations far below the danger point; chlorine by its characteristic suffocating odor, and ammonia by its sharp pungent odor. Chlorine is rapidly fatal to human beings after short exposure in concentrations of one part in one thousand of air, and ammonia in one part in two hundred. Both gases are dangerous to life even in considerably lower concentrations. The chemicals in the liquid form when in contact with skin give severe burns similar to thermal burns; this being especially true of liquid ammonia.

FIRST AID INFORMATION VITAL

Chlorine and ammonia gas are both powerful lung irritants and treatment of cases of persons affected by these gases is along similar lines. It is suggested that the instructions for "first aid" treatment for gassing or burns recommended by the committee on control of hazards from use of chemicals in water works plants of the American Water Works Association be posted in a prominent place in the plant. The committee recommendation for "first aid" treatment of chlorine gassing may be found in the September 1935 issue of the JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION; that on ammonia gassing and burns in the November 1936 issue of the same JOURNAL.

In case of accident "first aid" treatment should be applied pending the arrival of the plant physician who should take charge of the case.

The aforementioned committee report also contains the best available information on the treatment of severe cases of gassing. Since few physicians have had sufficient experience in the treatment of chlorine or ammonia gassing, or have readily available information regarding such treatment, it is a good idea to furnish the plant physician with a copy of this report in order that he may be prepared to give proper treatment in case of emergency. It is also advisable to have an understanding with the officials of the local Fire Department regarding the use of chlorine or ammonia in the water works plant in order that they may be prepared to give aid in case of accident.

In conclusion the writer desires to emphasize again that chlorine and ammonia gases can be used in water works plants with a minimum of risk if proper provision is made for storage and handling of the chemicals and if the plant operators have a thorough understanding of the properties of these chemicals and the proper methods of handling.

(Presented before the Wisconsin Section, October 6, 1936.)

EXPERIMENTS WITH SUB-SURFACE FILTERS AT TOLEDO, OHIO

BY R. W. FURMAN

(Commissioner of Water, Toledo, Ohio)

The City of Toledo Filtration Plant was placed in operation in February, 1910, and was designed to take care of the requirements of the city for approximately 25 years. The plans called for an ultimate capacity of 60 m.g.d. and included rapid sand filter units of 1 m.g.d. size.

Accordingly 20 filters of this size were placed in operation when the plant was started; 14 were added in 1912; and 22 more were placed in service in 1921. The first 34 filters contained a strainer system, 12 inches of gravel in small graded sizes, and 24 inches of sand. Washing was carried on with a wash water rise of 12 inches per minute. An air system consisting of $\frac{1}{2}$ -inch slotted brass tubes on 6-inch centers immediately on top of the finest gravel was used in connection with filter washing.

In 1916 the 34 filters were rebuilt and the strainer system was replaced with drilled laterals; the gravel depth was increased to 16 inches; and the sand to 24 inches. The sides of the wash troughs were raised 6 inches at the same time to allow an increase in wash water to 20 to 24 inches per minute according to requirements.

ADDITIONS TO PLANT NEEDED

By 1925 it became apparent that the 56 filters were rapidly approaching their capacity at peak periods and that steps must be taken for improvement of the entire supply if operation at over capacity rates was to be avoided. Accordingly a complete water survey was made and the report was published in 1928. Due to the fact that the plant was within 4 m.g.d. of the size for which it was designed, and because the demand for water indicated that the normal plant capacity would be exceeded not later than 1931, recommendations were made for the development of a new plant

with Lake Erie as a source of the supply. At this time recommendations were also made for enlarging the Maumee River plant sufficiently to take care of the demands for another 15 years.

Due to the lack of understanding on the part of the public for the necessity of some constructive plan for development of a future water supply and also to factional opposition to either of the proposed improvements no program was started. By the summer of 1930, a drouth year, the filtration plant became overloaded, and, due to the heavy usage of water, the filters were operated at rates up to 30 percent over their normal rated capacities. In the ensuing years several applications for government aid in improving these facilities were refused while the heavy over-load continued during the summers of each of the following years.

Some attention and consideration was given, in 1934, to a temporary means of increasing the filter plant output until a permanent and general program could be adopted. Quite naturally other operating problems were encountered due to the fact that some portions of the process were out of date or because facilities such as chemical feed or mixing and sedimentation were inadequate. The settling basins for example allowed too short a period of reaction and detention at high rates of pumpage, thus imposing a heavy burden on the filters that were already operating at over capacity rates. The washing of 56 filters, at periods of 4 hours or more, according to the amounts of algae and other plant and animal life encountered, necessitated careful operation. By using air and double wash when possible the sand was kept free from mud-balls and from excessive shrinking or cracking. The sand as originally placed had an effective size of 0.38 mm. but after years of continued use has increased in size to 0.58 mm. An average analysis of this incrustated material follows: total incrustant, 52.74 percent; insoluble, 12.79 percent; $\text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$, 36.73 percent; MgO , 1.23 percent; and CaO , 1.99 percent.

Late in 1934, due to a sharp increase in water consumption, on the part of industrial users, it became apparent that the summer demands would be excessive. Accordingly, temporary means for relief were again considered. In January, 1935, a trip was made to Kennilworth, Illinois, for the purpose of inspecting a system of sub-surface filtration which appeared successful at that plant. Through this installation filter capacities were reported to be increased 50

to 100 percent over the normal rating with a satisfactory effluent from both bacterial and physical standpoints.

EXPERIMENTAL EQUIPMENT INSTALLED

Later in the year it was decided to equip one filter at the Toledo plant for the purpose of conducting a series of experiments. The unit was installed in No. 56 filter in November and placed in operation on December 6, 1935. The old wash troughs, three in number, were raised 8 inches to allow increasing the sand depth from 24 to 34 inches in this filter.

The Jewell sub-surface filtering and washing system consists of two 10- x 10-inch manifold sections and 2-inch laterals connected to filter screens that are located under the surface of the sand on centers of 15 inches both ways. Applied water is introduced into the manifold through two 12-inch gate valves and a 12-inch pipe and flows to the screened filter heads which are located 8 inches below the surface of the sand layer.

The filter heads are made of stainless steel mesh screen set into a cage casting of hot-galvanized iron and locked by a nut at the bottom. A central pipe is included which is drilled with holes proportional to the area of the connecting manifold, the pipe being used for distribution of the applied water below the surface of the filter sand. Filtering is accomplished at rates up to 2 g.p.m. on the top of the sand as well as a rate up to 2 g.p.m. within the bed. This does not increase the speed through either the top sand or around the filter screens.

When properly flocculated the suspended impurities in the applied water may be collected on the top 2 to 3 inches of the sand, and, similarly if the floc is satisfactory, it is assumed that a second area will be set up around each of the screened filter heads. It is evident that the proper coagulation of colloidal particles must be accomplished to produce satisfactory filtration particularly in the use of sub-surface equipment.

METHOD OF WASHING

Washing of the sub-surface section is carried on at the same time the filter proper is washed through a connection from the main wash water line to the sub-surface manifold system. The 12-inch valves for supplying applied water to the system are closed while washing

is in progress. At the time the sub-surface unit was placed in operation, the washing of other filters was carried on at a rise of 21 inches per minute and the sand was expanded approximately 50 percent. The first time this filter was washed, the wash water was admitted at full rate in both the filter heads and through the regular reverse wash equipment. This resulted in expanding the sand to a point above the wash troughs and necessitated a change in wash methods to avoid the loss of sand. In consequence the old upward conventional wash was reduced gradually until it was found that a minimum rise of 4 inches per minute could be used together with a 27-inch rise through the sub-surface system. The total rise while using both upper and lower wash systems at the same time was 31 inches per minute. At this rise the sand expansion was found to be 21 percent. When the wash water had cleared sufficiently to see the sand it was disclosed that the downward high velocity jet action from the filter heads had created a rapidly moving, swirling mass of sand and water that remained 18 inches below the cutting edge of the wash troughs.

The erosive action of sand upon sand soon became apparent and the results of this method of washing was shown by the increased gravity of the sand and a pronounced decrease in the incrustant content from 34.5 to 29.2 percent. Individual sand grains when viewed under a microscope revealed that the incrustation was entirely removed from the high portions of the sand grains leaving a bright polished surface. Flat areas on the sand grains were worn thin enough to appear faintly opaque. Indented portions of the sand grains remained practically unchanged.

SPECIAL SAND STUDIES

For the purpose of studying further the removal of incrustated materials the sand was examined each two weeks by analyzing samples from the top and from points 8, 16, and 22 inches below the sand surface. Much shifting of sand occurred during this period, the lighter incrustated sand grading toward the top and the cleaner and heavier sand toward the bottom. The smallest removal of incrustation from the sand was noted in the top 8 inches or that portion above the filter heads. Gradually the percentage of incrustation increased in the top layer with but little evidence that the washing was affecting this light layer. The following analyses were made on the four layers of sand on March 16, 1936.

Percentage relationship between sand and incrustation

	TOP	8-INCH DEPTH	16-INCH DEPTH	22-INCH DEPTH
Total incrustant.....	41.7	19.3	12.3	11.8
Organic and volatile.....	22.3	10.8	7.1	6.1
Insoluble.....	6.9	4.2	1.4	2.9
Al ₂ O ₃ and Fe ₂ O ₃	12.0	4.3	3.8	2.8
CaO.....	0.5	Trace	Trace	Trace
Sand.....	58.3	80.7	87.7	88.2

The sub-surface filter was operated at the same rate as the remaining filters from December 6, 1935, to January 15, 1936, when the rate was changed from approximately 0.75 to 1 m.g.d. The rate was increased to 1.6 m.g.d. on January 23. During the period from January 23 to August 1, the rates of operation of this filter varied from 0.75 to 1.7 m.g.d. Due to the lack of capacity of the liquid counterweight for the control of the filter effluent, no attempt was made to filter at rates higher than 1.7 m.g.d.

OPERATING RESULTS

The bacterial figures up to the middle of May indicate a satisfactory effluent with results comparable to data collected from the effluent of other filters. From May 17, the tendency towards higher bacterial results was more pronounced in the sub-surface unit than in the other 55 filters. You are reminded at this point that mention was previously made of unsatisfactory conditions in the mixing and sedimentation basin, during high rates of pumpage, which imposed an undue burden on the filters. Under these conditions floc formation was imperfect and although the applied water turbidity was but slightly changed as regards its numerical value, the physical appearance offered a great contrast. Under the latter conditions the finely divided floc failed to separate bacteria and plant life to the extent desired in the basin proper. Under high rates of filtration with sand of 0.58 mm. size small quantities of colloidal floc, bacteria, and fragments of algae were forced through all filters in noticeable amounts.

On July 6, a sharp increase in the bacterial and turbidity content of the effluents from all of the filters, and particularly the sub-surface unit, led to an examination of the sand around the filter heads. The applied water at this time contained an unusually large amount of

algae and bryozoa. From the appearance, when examined, this plant life had been further reduced to fragments by the washing operation and more or less thoroughly distributed through the entire filter bed in the shape of particles of almost microscopic size. The applied water indicated that the disintegration of algae had been practically complete by the time the water had reached the filters, although the sedimentation basin had been in use less than 15 days.

CHANGE IN WASHING METHODS

As a result of these findings, the filters were subjected to a more thorough cleaning and a change was made in washing the sub-surface filter to avoid if possible further breaking of plant life within the sand area. A 24-inch per minute rise, without the use of the sub-surface wash, was used for approximately two minutes. This was followed by a reduction in the reverse wash to a 6-inch rise in connection with an additional 25-inch rise through the filter heads. This apparently was adequate to assure a satisfactory cleaning of the filter. Sufficient time has not elapsed to prove the contention. However, it is assumed that a more gentle flow of wash water at the start, entirely through a reverse or upward flow, had the tendency to remove algae etc., without the destructive jet action of the filter heads in washing.

It is evident from the foregoing that the same results may not prevail if proper coagulation, sedimentation, and detention is provided and similarly if sand of a smaller size is used. It is expected that a program of improvement will be immediately started at the Toledo plant that will include reconstruction of the settling basins and the installation of flocculators. It is planned to continue the tests on the sub-surface filter using sand with an effective size of 0.38 to 0.40 mm. in place of the coarser material.

CONCLUSIONS

In most instances the high consumption period is confined to about three months of the year and for the balance of the time most plant facilities are adequate. For this reason, the sub-surface system is of interest in the respect that it allows its use for extra filter capacity when required and also seems to provide an improved method of washing at all times of the year.

No data are available regarding the inconvenience and expense involved when filter repairs are necessary on account of the extra

pipe which must be removed when this system is involved. It is expected that the new design will minimize this fault.

It has been suggested that higher rates of filtration may be provided by the use of coarse sand, however, this would have a tendency to produce an unsatisfactory effluent during the entire year. This is especially true in plants where fine sand is desired, when in reality the extra capacity is needed for only a few months.

The desirability of this system will no doubt be determined by its comparative cost, the difficulty faced by some plants in expanding by the addition of new filters, and whether added capacity by this means is justified at the possible expense of slightly increased effluent turbidity for a short period of time.

There is no indication that the filter heads have shown signs of failure during the 8 months of operation. There is no evidence that the screened section has become clogged or that the sand has passed through the mesh into the cage proper.

The lower layers of sand below the 8-inch depth have remained clean while the top layer shows but little signs of further reduction in its incrustant coating. It is believed that if the upper sand is clean at the start there will be little tendency for incrustation.

Further observations will be made during the coming year using new, clean sand of smaller size for the filter.

(Presented before the Central States Section, August 19, 1936)

HOW MUCH WATER DO WE CONSUME?

HOW MUCH DO WE PAY FOR IT?

BY CHARLES H. CAPEN, JR.

(Engineer, North Jersey District Water Supply Commission, Newark,
New Jersey)

INTRODUCTION

Questions as to volume and cost of water consumed are readily propounded but not easily answered. Very few waterworks men can give more than a very general answer to the question asked in the title given above.

Rule of thumb methods, while very useful in the early days of water supply development, are gradually giving away to established facts. One of the oldest rules was that a water supply should be designed on a basis of 100 gallons consumption per capita per day. Voluminous data have been published on the subject but the facts have not always been assembled in such a way as to permit drawing definite conclusions. The following discussion will serve to throw some light on the matter of per capita consumption of water, together with the relationship between consumption, revenue and population.

GROWTH IN POPULATION AND CONSUMPTION

It is fairly well established that as a city grows in size, the per capita rate of consumption increases. There are several reasons for this, among which are: greater industrial use, arrival of many visitors and commuters who are not residents, (particularly during the day-time), increase in demands for street washing and sewer flushing and other municipal uses. This increase starts off fairly slowly with small residential communities, increases at a more rapid rate as the characteristics change to those of a city, and finally tends to reach a saturation point.

DATA AVAILABLE

To aid in establishing the general trend of increase that may be expected, various reports of water consumption have been examined. Probably the most comprehensive contribution in recent years is that

published by the American Water Works Association (1). In fact the information presented is so voluminous as to be almost overwhelming and it includes so many minor supplies that a complete study of it would not only be tedious but unnecessary. The more recent compilation by Rudd and Michael (2) presents a much briefer but apparently more reliable tabulation and contains figures on revenue, thereby permitting a study of the correlation of consumption, revenue and population.

In addition to the aforementioned tables, the writer has had access to the annual reports of all water supplies in New Jersey as made to the Board of Public Utility Commissioners and the annual reports of the N. J. State Department of Health, whereby a fairly accurate comparison of a large number of supplies was obtained.

USE OF DATA

Taking the tables of the A. W. W. A. (1), the per capita consumption was computed for all supplies delivering water to more than ten thousand people, including however, only those wherein the estimated population supplied was definitely set forth. This was done for filtration plants and simple chlorination plants, both groups being further subdivided into municipal and private supplies. For each of these four classes, summaries were made, grouping the average results of population as shown in table 1. These figures are for the year 1930 and may be expected to be somewhat higher than for subsequent years.

The A. W. W. A. booklet states that the average per capita consumption in the United States in 1930 was 132 gallons per day. This is a weighted average obtained by dividing the total water consumption listed by the total population listed. Although the statement is probably correct, it does not lend a true appreciation of variations of consumption with population.

The results of table 1 are distinctly irregular and do not permit very definite conclusions as to per capita consumption. From a careful analysis of the data assembled to make the table, it appears that the many cases of supplies in certain unusual industrial centers far outweigh the general average and give distorted results. For example, there are several cases of per capita rates from 200 to nearly 700 gallons per day. In almost every one of these cases, the name of the municipality involved brings to mind some large industry which would undoubtedly use a vast amount of water. An example is the

privately owned system at Anaconda, Montana, where the per capita rate is 422 gallons per day. The population served is only 12,529 and the effect of this one figure raises the average per capita rate in that class 14 gallons per day. While industrial use accounts for a large per cent of all water consumption, in most municipalities unusual cases of this sort can hardly be classed as normal.

Rudd and Michael have canvassed over fifty supplies, giving a fairly representative cross section of the entire United States for the year 1932. For these the following items were computed: gallons per capita per day, revenue per capita per year and revenue per million gallons. Using these values as ordinates, together with population, points were plotted for the various combinations possible with the four variables, on regular, arithlog and log paper and in one case a series was arranged and plotted on arithmetic probability paper. None of these charts are presented herewith because for the main part they are not sufficiently conclusive to permit more than a general interpretation of the trends. In their place, summaries were made by grouping the average results according to population, as was done in the preceding case, and these are given in table 2. (Note: An investigation by the writer showed that some of the figures obtained by Rudd and Michael have since been revised and the table includes the revisions.)

This table, representing cities in about half of the states in the Union and two Canadian provinces, the records of which were carefully compiled and checked, deserves much greater consideration than table 1. The per capita rate in gallons per day shows a very definite increase with an increase in population. With the omission of one case that seems obviously out of line, the increase is surprisingly uniform. The revenue per million gallons also shows a very definite trend. It is apparent that quantity production permits lower prices in water as in other commodities. Revenue per capita tends to show a somewhat lower rate as population increases, but the irregularity leads to the conclusion that greater industrial, commuter and municipal uses largely off-set the reduction that might otherwise be expected with an increase in population. The figures obtained lie between those given by Metcalf (3) for 1923 and the \$6.00 per capita revenue cited by Howson (4) in 1933. It seems probable that if individual water bills for domestic service could be carefully examined, the per capita revenue would follow a course similar to that of the revenue per million gallons.

As a comparison and check, similar data for 1932 were taken for all supplies in New Jersey involving more than 1,000 population, excepting those supplies that are greatly influenced by summer population. (For the most part these latter are located at seashore resorts.) Points were plotted as before but again the results did not permit drawing accurate curves and have therefore been omitted. However, table 3 shows the result of a tabulation of averages similar to tables 1 and 2, except that the range of population is from 1,000 to 500,000 instead of the higher population values used in the preceding tables. An important point that was taken into consideration in making table 3 was that where one supply serves a number of dif-

TABLE 1
Water consumption in the United States in 1930
Average gallons per capita per day

POPULATION RANGE	FILTRATION PLANTS				SIMPLE CHLORINATION PLANTS			
	Publicly owned		Privately owned		Publicly owned		Privately owned	
	Gallons	Number of supplies	Gallons	Number of supplies	Gallons	Number of supplies	Gallons	Number of supplies
10,000 to 20,000	132	93	112	55	159	40	134	22
20,000 to 50,000	113	75	104	35	150	23	126	17
50,000 to 100,000	137	25	101	16	130	16	122	5
100,000 to 200,000	122	17	81	4	106	5	68	2
200,000 to 500,000	116	13	102	3	116	4	163	2
500,000 to 1,000,000	159	5	86	1				
Over 1,000,000	148	3			209	3		

ferent municipalities, the type and location of these municipalities was studied and in most cases an average population was used rather than the total. As an example, the extreme case showed one supply serving over 400,000 people scattered throughout more than fifty municipalities, ranging from very small suburban communities to fairly large industrial cities. It would be obviously erroneous to assume that the entire population so served should be considered as one large city having the total population indicated.

As a general comment on the results given in table 3, considerable weight may be given to the figures for revenue and quantity of water because of the requirements of the various state departments in New

Jersey with regard to reporting accurately. The excess water diversion tax in particular, has a strong influence on obtaining reliable water consumption data. Only in the matter of population served is there apt to be any element of unusual variation in estimates, a condition which would hold true in all parts of the country.

In the preparation of table 3, it was noted that the computed figures for municipalities in the population range of 50,000 to 100,000 were rather abnormal. There were two supplies in this class, both of which operate under certain peculiar conditions that probably do not exist in any other part of the United States. The writer therefore has made some estimates to counteract the conditions and has presented not only the actual figures but also corrected values.

It may be further noted in table 3 that the per capita rate in the 100,000 to 200,000 population class is out of line and is greater than in the next higher population class. This situation has been studied and the cause may be almost wholly attributed to incomplete metering and large specific industrial usage.

DEDUCTIONS FROM DATA

Taking the figures from tables 2 and 3, points were plotted on logarithmic paper for both per capita consumption and revenue per million gallons, as compared with population. The results are shown in figures 1 and 2 respectively. In each case the plotted points have been designated by shape so as to indicate from which table they have been taken. For all practical purposes however, it may be said that tables 2 and 3 are in reasonable agreement in so far as these curves are concerned.

In addition on figure 1, there have been added two secondary curves, one representing the average consumption which might be expected with a fairly high percent of metering and waste elimination, the other representing probable consumption with complete metering and stringent waste regulation control. No corresponding curves have been drawn on figure 2 because a reduction in consumption following metering and waste elimination is not followed by a proportionate reduction in revenue. To estimate the final outcome would involve a separate study that would have no place in the present discussion. These curves give, in general, substantially higher rates of per capita consumption than those presented by Metcalf (5), who based his findings largely on meter rates. It seems probable that pressure is equally important. In the general effort to obtain fire

flows suitable to the underwriters, the effect of the increases in pressures on per capita consumption does not appear to have been given

TABLE 2

Water consumption and revenue for 52 cities in the United States and Canada in 1932

POPULATION RANGE	AVERAGE CONSUMPTION, GALLONS PER CAPITA PER DAY	AVERAGE REVENUE PER MILLION GALLONS	AVERAGE REVENUE PER CAPITA	AVERAGE POPULATION	NUMBER OF SUPPLIES
20,000 to 50,000	85	\$187	\$5.38	33,000	7
50,000 to 100,000	103	150	5.15	64,000	10
100,000 to 200,000*	118	130	5.14	132,000	11
200,000 to 500,000	110	116	4.38	325,000	14
500,000 to 1,000,000	138	93	4.51	873,000	5
Over 1,000,000	167	74	3.87	3,034,000	5

* Omitting one city which is obviously out of line, the figures for this class become as follows: 107; \$135; \$5.00; 135,000 and 10 respectively. These latter figures were used in plotting the curves.

TABLE 3

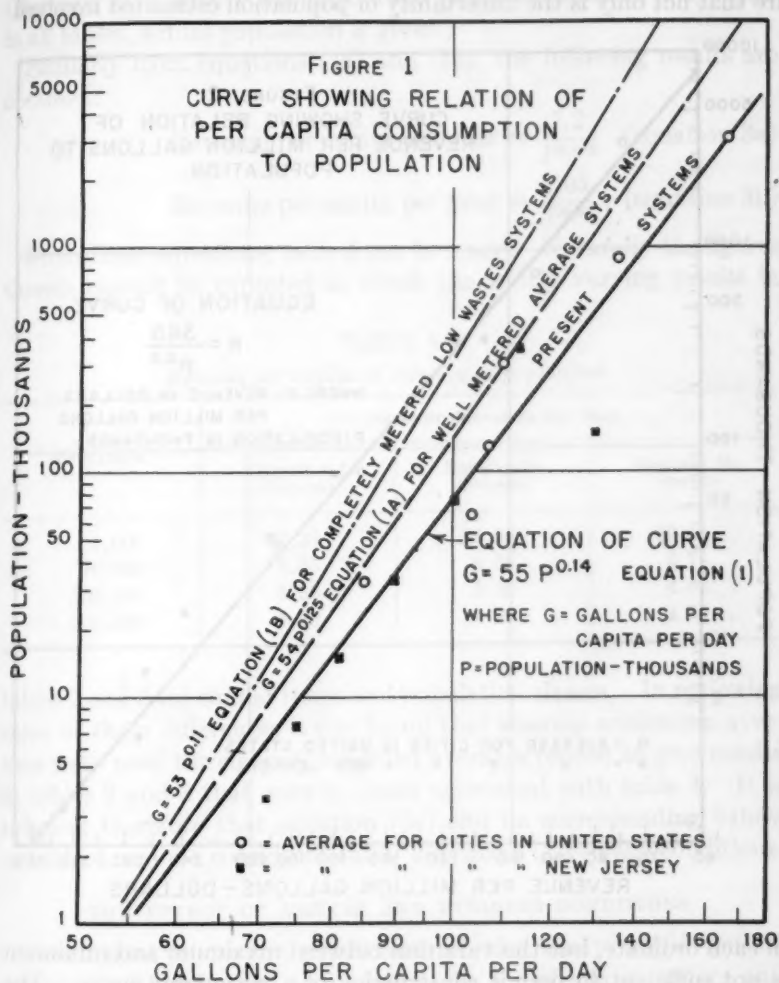
Water consumption and revenue for 113 supplies in New Jersey for 1932

POPULATION RANGE	AVERAGE CONSUMPTION, GALLONS PER CAPITA PER DAY			AVERAGE REVENUE PER MILLION GALLONS, DOLLARS			AVERAGE REVENUE PER CAPITA, DOLLARS			NUMBER OF SUPPLIES		
	Municipal	Private	Average	Municipal	Private	Average	Municipal	Private	Average	Municipal	Private	Total
1,000 to 2,000	54	61	56	\$336	\$316	\$330	\$6.00	\$6.20	\$6.07	17	7	24
2,000 to 5,000	73	70	72	271	271	271	5.88	6.56	6.10	19	8	27
5,000 to 10,000	77	70	75	244	317	264	6.01	6.67	6.23	17	7	24
10,000 to 20,000	85	73	81	212	295	239	5.42	7.26	6.00	11	5	16
20,000 to 50,000	90	83	89	175	294	190	5.47	8.88	5.90	7	1	8
50,000 to 100,000	89		100*	195		160*	6.31		5.50*	2		2
100,000 to 200,000	130		130	114		114	5.47		5.47	3		3
200,000 to 500,000	113		113	107		107	4.30		4.30	2		2

* Revised estimate—see text.

due consideration. Rainfall, temperature and geological features probably all have an influence but this is apt to be less than might be generally supposed.

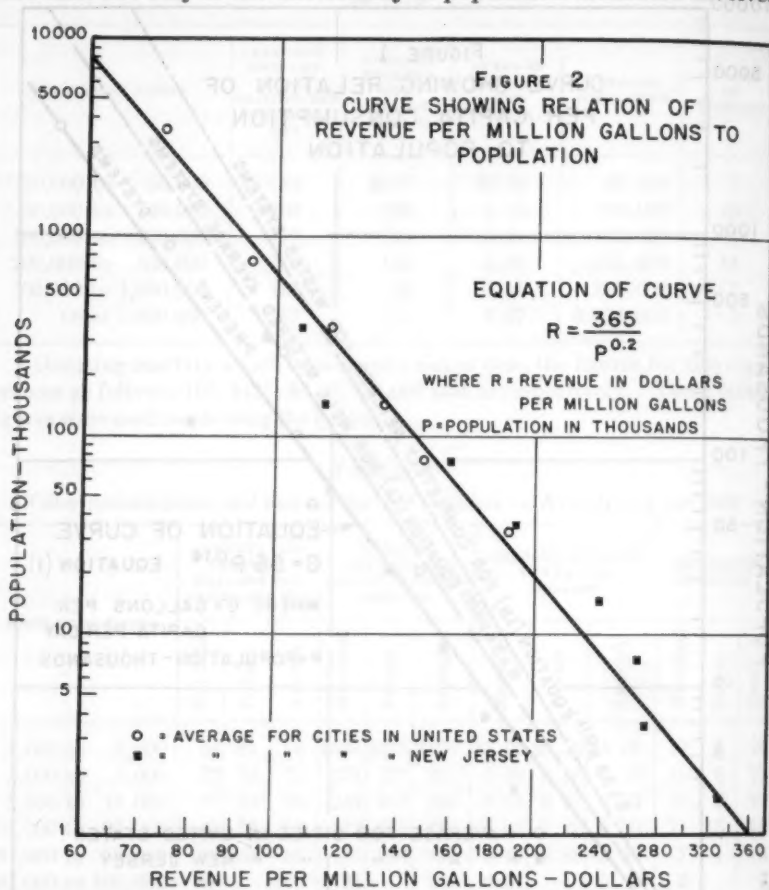
Equations for the curves have been determined and are shown in approximate or simplified form in the figures. Assuming that the revenue and total water used by the supplies have been reported in a reasonably correct manner, it follows that the revenue curve, figure 2,



is the more reliable of the two because it involves only one uncertain ordinate, i.e., population. Conversely, the per capita consumption, involving population in both ordinates, is bound to be less dependable. The range of both revenue per million gallons and per capita consump-

tion is sufficiently great to permit construction of curves on reasonably spaced ordinates.

By comparison it may be seen that the reasons why no curve has been drawn for revenue per capita per year in relation to population, are that not only is the uncertainty of population estimated involved



in each ordinate, but the variation between maximum and minimum is not sufficient to permit construction of a reasonable curve. The equations for figures 1 and 2, however, immediately suggest a method for a theoretical determination. Multiplying equation (1) (figure 1) by the proper constant converts it into million gallons per capita per year. Then multiplying this revised equation by equation (2)

(figure 2) gives the revenue per capita per year whence the result obtained is approximately:

$$\text{Revenue per capita per year} = \frac{7.3}{P^{0.006}} \quad (\text{equation 3})$$

(Revenue is in dollars and population (P) in thousands. Note that in all tables, actual population is given.)

Similarly from equations (1a) and (1b), the following results are obtained:

$$\text{Revenue per capita per year} = \frac{7.2}{P^{0.076}} \quad (\text{equation 3a})$$

$$\text{Revenue per capita per year} = \frac{7.05}{P^{0.02}} \quad (\text{equation 3b})$$

From these equations, table 4 can be made. Naturally the figures therein cannot be expected to check the widely varying results in

TABLE 4
Revenue per capita in relation to population

POPULATION	REVENUE PER CAPITA PER YEAR		
	Equation 3 (highest)	Equation 3a (average)	Equation 3b (lowest)
1,000	\$7.30	\$7.20	\$7.05
10,000	6.35	6.05	5.75
100,000	5.55	5.10	4.65
1,000,000	4.80	4.30	3.80

tables 2 and 3 for similar items and population classes. In reviewing some of these differences it was found that whereas arithmetic averages were used throughout, weighted averages tended to give results in tables 2 and 3 that were in closer agreement with table 4. It is believed therefore that equation (3a) and its corresponding values in table 4 may be considered fairly indicative of average conditions.

THE EFFECT OF METERS AND BUSINESS CONDITIONS

Conclusions as to the significance of this study would not be complete without a few comments as to the effects of meters and business conditions. Table 5, indicating the percent of services metered and the other variables herein discussed, for the City of Newark, New Jersey, shows both of these very clearly.

The decrease in per capita use even during the war period, as a

result of metering, is quite evident. The effect of the business slump in 1921, with subsequent recovery during the next few years, culmi-

TABLE 5

*Meters and business conditions in relation to per capita consumption and revenue
Newark, New Jersey*

YEAR	POPULATION	PERCENT SERVICES METERED	GALLONS PER CAPITA PER DAY	REVENUE PER MILLION GALLONS	REVENUE PER CAPITA
1910	347,469				
1914		58.8	119	\$82	\$3.60
1915	366,721*	60.6	114	81	3.45
1916		64.8	123	84	3.85
1917		88.1	116	85	3.65
1918		89.9	113	85	3.70
1919		90.7	104	89	3.55
1920	414,524	92.2	109	89	3.75
1921		92.7	96	93	3.50
1922		93.9	101	91	3.60
1923		94.3	106	90	3.75
1924		95.2	105	90	3.80
1925		95.3	105	91	3.90
1926		95.6	106	92	4.15
1927		95.6	105	92	4.10
1928		97.0	108	92	4.20
1929		96.8	114	93	4.40
1930	442,337	96.8	111	93	4.30
1931		97.2	103	99	4.15
1932		97.6	94	97	3.90
1933		97.0	91	102†	3.95†
1934		97.0	101	105	4.55
1935		98.1	101	105	4.55

* State Census. All other populations are from Federal Census. Intermediate populations are not shown as they differ slightly from Newark Water Department estimates. Per capita rates are correspondingly affected.

† Rates increased by a 15 percent surcharge in October 1933.

nated in the high peak of 1929. The history of the next few years is also self-explanatory. Needless to say, the whole table is a marked exhibit of the value of metering in reduction of consumption.

SUMMARY

No attempt has been made to go into detailed comparison between supplies that are pumped and those that are not, or to consider type of industries, territory served, pressure, percent of services metered, condition of distribution system or nature of supply. These and many other features might be studied in some detail but the value of such differentiation would be doubtful in a general discussion of this kind. They might however, be useful in comparisons of individual supplies with others of a similar type. The writer knows of one case where a city made a detailed study of rates by comparing its rates with those of others of a similar type and population, with the result that the water department was able to show that its much needed increase in rates was well justified.

Allowance must be made for the fact that the figures given represent the years 1930 and 1932, the data for the curves having been taken in the latter year. In 1930 the impetus of the boom period continued and water consumption and revenue were in general about equal to those existing in 1929. In 1932, water consumption had dropped about 12 percent below the 1929 level but probably less than 10 percent below a normal level. Since the loss of consumption was largely industrial, or low priced water, gross revenue was only about 6 percent below 1929 and only about 4 percent below normal. Conversely, revenue per million gallons was about 4 percent above normal.

The low ebb of water consumption during the depression occurred early in 1933 and a definite upward trend started in October of that year. Consumption records since that time reflect very definitely a generally rising course. However, the rise has been tempered by the very effective drive on water waste instituted by many water departments under the stress of economy measures to curtail all reasonably reducible losses. In some instances unmetered or partially metered supplies have reduced consumption by adding more meters.

All of these factors have been taken into consideration and it is believed that equations (1a) and (3a) are indicative of average conditions to be expected now and for a reasonable time in the future while equation (2) may give results that are slightly too high. This conclusion seems to be substantiated by a tabulation made (but not reproduced herein) of the water output and revenue of about thirty supplies for the years 1928 to 1935 inclusive, wherein the trends of both these items are fairly well demonstrated.

One of the best discussions of per capita consumption has been given by Whitman (6) who has aptly said that "the water consumption of each individual place is a problem all to itself." The writer has no intention of trying to dispute this obviously true statement. It is believed, however, that there has been demonstrated herein a definite general relation between the various main factors discussed.

CONCLUSION

In conclusion it may be said that as population increases, per capita consumption increases, while revenue per million gallons and revenue per capita per year decrease. For any one supply, where marked deviations from the curves occur, the explanations may generally be found in one or more unusual conditions which exist in that particular case.

The curves are presented therefore, in the hope that water works men may use them to advantage in comparing their individual problems with average conditions and may thereby be guided in their policies concerning their own supplies.

(Presented before New York Section, December 29, 1936.)

BIBLIOGRAPHY

- (1) American Water Works Assoc. "Census of Municipal Water Purification Plants in the U. S.—1930-31." 1933.
- (2) RUDD, WM. C. AND MICHAEL, ARTHUR C. "Income and Operating Costs." Jour. A. W. W. A. 26, 6; June 1934. P. 793.
- (3) METCALF, L. "The Financial Status of Water Works in the United States as of January 1, 1924." Jour. A. W. W. A. 13, 4; April 1925. P. 375.
- (4) HOWSON, L. R. "Water Rates and Construction Policies in Municipally Owned Plants." Jour. A. W. W. A. 25, 1; January 1933. P. 79.
- (5) METCALF, L. "Effect of Water Rates and Growth in Population upon Per Capita Consumption." Jour. A. W. W. A. 15, 1; January 1926. P. 1.
- (6) WHITMAN, E. B. "Per Capita Consumption." Jour. A. W. W. A. 24, 4; April 1932. P. 515.

RATES CHARGED FOR INDUSTRIAL WATER IN OHIO

By PHILIP BURGESS

(Consulting Engineer, Columbus, Ohio)

One of the most interesting and important problems which come to the attention of those in charge of the operation of water works properties is that of establishing a proper charge for water sold to large industrial consumers. Fortunately, the situation has been somewhat clarified in Ohio because about one year ago the City of Youngstown introduced new steps in its water rate schedule and offered water to large consumers at very low rates. Shortly thereafter, certain taxpayers sought to restrain the City from putting these rates into effect on the ground that water would be sold at less than cost and further that rates to large consumers discriminated against the small consumer. After a somewhat lengthy hearing, the City was restrained from enforcing these low industrial rates on the ground that they were discriminatory. It is the purpose of this paper to attempt to show some of the questions which were decided by the Court in arriving at his decision, questions bearing upon the methods properly to be used in computing a fair and equitable rate chargeable to large water consumers.

FACTORS IN RATE MAKING

The establishment of a proper rate requires consideration of such factors as (1) the adequacy of the supply of water which it is proposed to sell, (2) the cost of the water supply as a whole and as distributed between the many customers attached to the system, (3) the relation of the rates properly chargeable to various classes of customers, and (4) the value, or worth, of the service rendered to the various customers.

It is a well recognized principle of rate making that a customer shall pay only his fair portion of the cost of service rendered but the principal trouble generally encountered in formulating a proper rate schedule occurs through the difficulty experienced in allocating the proper costs to the various classes of customers attached. Some of

the difficulties encountered in fixing a proper industrial rate have been discussed and clarified in the case above mentioned.

THE YOUNGSTOWN RATES

The proposed rates offered water to customers at very low prices, namely, 40 and 30 cents per thousand cubic feet. Before discussing the propriety of offering such low rates it is necessary, first, to understand what costs are properly chargeable to the service.

In the Youngstown case, the situation was peculiar and differed from the ordinary water property in that the supply is obtained from a Sanitary District through a master meter and is delivered to some 30,000 active customers. The rates at which the City purchased the water were determined by the Court and the City had the right to fix only the rates which it charged to its water customers. For the year extending from July, 1934 to June, 1935, a schedule of rates was established for water purchased by the City on a sliding scale basis ranging from \$0.0435 per thousand gallons for a total consumption of 11 million gallons, or less, to a rate of \$0.032 per thousand gallons when the gross sale for a month was 20 million gallons or more. It is obvious that the slide in this scale materially affected the unit cost of water purchased by the City so that the sale of industrial water at low rates appeared to be attractive as reducing the unit cost of all water purchased. The more water the City sold, the less it paid for a million gallons purchased from the District.

One of the factors generally of primary importance as affecting the cost of water service, is the cost of the supply. The total development of the works provided to supply the Cities of Youngstown and Niles was \$9,456,000, and interest charges total \$5,961,925.00. The total financial expense involved in the development of the supply was, therefore, \$15,417,925. Under the usual distribution of costs of a water department, whether privately or municipally owned, it would be necessary to distribute these costs equitably among all the customers served. Under the method of constructing and financing the supply at Youngstown, however, bond and interest charges are a direct lien on all taxable property in the district. Up to ninety per cent of the financial cost can be met out of water revenues only in the event that either City has a surplus in its waterworks funds available for this purpose. Actually, bond and interest charges have been paid out of revenues received at Youngstown only to a minor extent.

SMALL USERS RATES LOW

Investigations disclosed that the average small water consumer at Youngstown actually paid approximately one-half of his total cost of water used through bills rendered by the water department and the other half of his total water cost is paid in the form of tax rendered on the value of his property, both real and intangible. In other words, if the small water consumer paid for all water used directly as a charge for the water, his water bill would be increased approximately 100 percent. This feature of distribution of cost is important in comparing the Youngstown situation with that of other communities.

It is, of course, true that all operating costs of the water department, including interest costs, general costs and cost of supply must be distributed fairly among consumers if the rates are to be equitable. In the Youngstown case above mentioned, these costs totaled \$504,803.52 for the year 1934. Under the present system of charging for water at Youngstown and at other Ohio communities, all of these costs are met through the sale of water because there are no assessments and no direct revenues received for public fire protection and for general service to the City for parks, street sprinkling and other uses. These costs must be met, therefore, entirely from revenues derived from the sale of water.

The taxpayers complained that the low rates proposed would sell water to large consumers at less than cost and, in presenting its argument and testimony with respect to costs, the City's witnesses showed that costs of city service including public fire protection and general city uses amounted to \$94,712.67 annually. Similarly, they found that the cost of boosting or increasing the pressure to customers situated on high ground amount to \$70,867.55. The City contended in the Youngstown case that none of these costs were properly chargeable to industrial water.

THE COURT'S DECISION

In rendering his decision in the Youngstown case, the Court sustained the position taken by the City and eliminated the two amounts outlined above with the understanding that no part of these costs entered into the costs of the water sold for industrial use to the large consumers, all of whom were located in the low pressure district.

One of the methods commonly used in computing industrial water rates is to figure only the so-called "Out-of-Pocket Costs" on the grounds that the water department has to operate any way and that, if the above costs are exceeded by the revenue obtained by the sale of large quantities of water, then such sales at low unit costs are justified. In the Youngstown case, the City went so far as to claim all of the benefit for the large consumers resulting from the reduced costs of water sold to the small consumer.

The Court found that it was improper to figure industrial rates on the basis of a separate service and on the basis of "Out-of-Pocket Costs" only. In the Court's decision, we find the following:

"It is not the 'additional cost' of the anticipated additional water that we are seeking, it is rather the cost of water purchased after the present consumers and the additional customers *as one compact whole* are taking water. If the opposite view be taken then the cost of water chargeable to each new additional customer indefinitely in the future becomes fixed as to each new consumer at the time his account is opened and we have countless variations in the costs of the same commodity."

This decision is important and is supported by an opinion of the United States Supreme Court recorded in the case.

"In Northern Pac. Ry. Co. vs. State of North Dakota, 236 U. S. 585, the United States Supreme Court states the principal, at page 596:

"We find no basis for distinguishing in this respect between so-called 'out of pocket costs' or 'actual' expenses, and other outlays which are none the less actually made because they are applicable to all traffic, instead of being exclusively incurred in the traffic in question. Illustrations are found in outlays for maintenance of way and structures, general expense and taxes. It is not a sufficient reason for excluding such, or other, expenses to say that they would still have been incurred had the particular commodity not been transported. That commodity has been transported; the common carrier is under a duty to carry, and the expenses of its business at a particular time are attributable

to what it does carry.... The outlays that exclusively pertain to a given class of traffic must be assigned to that class, and the other expenses must be fairly apportioned. It may be difficult to make such apportionment, but when conclusions are based on cost the entire cost must be taken into account.' "

WHEN IS A RATE DISCRIMINATORY?

From the above discussion, we may then make certain conclusions with respect to the proper methods to be followed in determining equitable rates chargeable to industrial consumers, as follows:

In making such computations of cost it is proper to consider all costs of the water department including capital, general and administration costs; that it is not proper to include costs as applied to service rendered in which the customer in question has no direct interest, such as public fire protection, general city use and booster pumping costs; that costs of special service such as public fire protection and booster service are properly allocated to costs of water sold to the smaller consumers who benefit from such service, in the event that these costs are not met in some other manner. We may infer, also, that private fire protection should be paid for at cost.

It is, of course, true that a rate must not only be reasonable but it must also be non-discriminatory. One of the first questions involved is—What is discrimination? In the Youngstown case, the Court defined discrimination as follows:

"To discriminate may be defined as to make a difference in treatment or to favor;" (Webster's International) also "to make an unfair or injurious distinction."

We may properly assume from the above definition, therefore, that a water rate to be fair must be predicated upon similar treatment without injurious distinction between various classes of customers. Doubtless, this means that costs of service must be computed on an equitable basis and that when a percentage of profit accrues it should be substantially the same to all classes of customers.

It is a well established principle of law in Ohio that a water works department cannot operate with a view to creating a profit. "It is a coöperative enterprise and any surplus can only be dealt with in accordance with statutes."

RESTRICTIONS UPON A MUNICIPAL UTILITY

It is also recognized that "a municipally owned utility is subject to the same restrictions as to rates and terms of service as a privately owned one."

A citation appears in the Youngstown decision as follows:

"Butler vs. Karb, Mayor, 96 O.S. 472, wherein Judge Matthias states the principal on page 485 as follows:

"It is averred by the plaintiff that these officers having assumed such power and authority in the absence of a system or schedule of rates duly and properly adopted by council are using that power to discriminate between citizens with reference to furnishing the product of the city's plant, and particularly as to rates charged therefor. That such discrimination constitutes an abuse of power there can be no question. That neither public nor private corporations may discriminate between members of the public with reference to rates and terms of service does not longer admit of controversy. This wholesome rule, long in force, has had frequent application, particularly to common carriers and utility companions. A municipality operating a utility is not exempt therefrom. Acting in a proprietary capacity, we have seen, it should have the freedom of action of a private utility corporation, but it is also subject to the same restrictions as to practices of discrimination in rates and service.'"

A further point of law in Ohio today is that a rate is not justified upon the grounds of "expediency." In the Youngstown case it was admitted by both sides that the proposed low rates to industrial consumers would permit an increase in Net Income enjoyed by the Water Department of the City of Youngstown. However, the language of the Court in this case is "whatever may be the expediency of the situation, of course, can have no bearing on whether there is discrimination. If there is discrimination, expediency can not justify it."

Water works operators frequently do not recognize the justice or propriety of this point of law. Situations are not uncommon where sales of water to large industrial consumers increase the net profit of the department, but this fact alone does not justify such low

rates which may or may not be discriminatory with respect to customers in the low consumption brackets. On the other hand, a water works operator frequently faces the situation that he has an excess of water to sell but through competition with other supplies that may be available he can sell water at only a certain maximum price fixed by what the "traffic will bear." It is unquestionably true that, in many instances, "expediency" has improperly been considered to justify low rates which may be discriminatory.

PREVIOUS RATE STUDIES

Much has been written in the past with respect to proper methods of determining rates for water service charged to both large and small consumers. The New England Water Works Association and the American Water Works Association have, in the past, appointed committees of representative water works men and engineers to report on Meter Rates. The reports of these committees have been received and adopted by the Societies. It is significant that, in each of these reports, the Committees recommended that a sliding scale in a meter schedule should seldom contain a spread exceeding a ratio of 3 to 1 between the highest and lowest rates.

In the discussions written into or following these committee reports, much was said about sliding scales and particularly as to the maximum spread that properly may be used in a schedule. It is significant that it was only after much study and discussions in open conventions that the above maximum ratio, namely, 3 to 1, or occasionally 4 to 1, was reported to and accepted by both of the Water Works Societies.

In connection with the Youngstown case, the question of discrimination was of great importance. The ratio of cost in the sliding scale between the largest and smallest customers, as stipulated in the schedule was 10 to 1. The Court found this to be discriminatory. He found further that there was over 300 percent profit on the rate charged to the small customer whereas, under the proposed schedule, water would be sold to the industrial consumers at or near cost.

From the above, it is proper to assume that, in computing a water rate schedule, it is necessary, first, to determine actual costs of the service as rendered to the various customers and, second, to establish rates which do not give undue profit obtained from certain groups of customers as compared to other groups which give a substantially less, or greater, percentage of profit to the water works department.

TABLE 1
Rates charged for water in certain cities in the United States

NAME OF MUNICIPALITY	APPROXIMATE NUMBER OF SERVICES	RATES PER THOUSAND GALLONS		RATIO
		Maximum	Minimum	
Philadelphia, Pa.....	400,000	0.133	0.053	2.5
Detroit, Mich.....	272,000	0.087	0.052	1.7
(Service charge $\frac{1}{4}$ -inch meter = 1.20 per quarter; service charge 8-inch meter = 36.80 per quarter)				
Baltimore, Md.....	195,000	0.27	0.10	2.7
Cleveland, Ohio.....	164,000	0.104	0.08	1.3
Pittsburgh, Pa.....	130,000	0.20	0.14	1.4
Cincinnati, Ohio.....	110,000	0.16	0.067	2.4
Buffalo, N. Y.....	99,000	0.133	0.053	2.5
Minneapolis, Minn.....	93,000	0.10	0.10	1.0
Portland, Oregon.....	86,500	0.147	0.107	1.4
St. Paul, Minn.....	62,700	0.12	0.04	3.0
(Service charge $\frac{1}{4}$ -inch meter = 1.05 per quarter; service charge 8-inch meter = 105.00 per quarter)				
Columbus, Ohio.....	60,000	0.16	0.08	2.0
Atlanta, Ga.....	56,000	0.167	0.12	1.3
Paterson, Passaic and Clifton, N. J.....	55,000	0.153	0.04	3.8
Peoria, Ill. (private company).....	23,000	0.667	0.093	7.2
Richmond, Va.....	42,000	0.147	0.067	2.2
Grand Rapids, Mich.....	38,000	0.113	0.087	1.3
Des Moines, Iowa.....	32,000	0.30	0.07	4.3
Bridgeport, Conn.....	30,000	0.20	0.08	2.5
(Service charge $\frac{1}{4}$ -inch meter = 2.50 per quarter; service charge 8-inch meter = 90.00 per quarter)				
Long Beach, Calif.....	28,000	0.253	0.08	3.1
Reading, Pa. ($\frac{1}{4}$ -inch to $1\frac{1}{4}$ -inch).....	27,000	0.245	0.08	3.1
Camden, N. J.....	25,000	0.25	0.10	2.5
(Service charge $\frac{1}{4}$ -inch meter = 3.13 per quarter; service charge 6-inch meter = 18.75 per quarter)				
Knoxville, Tenn.....	25,000	0.333	0.12	2.6
New Haven, Conn.....	25,000	0.267	0.08	3.4
Duluth, Minn.....	23,000	0.20	0.08	2.5
Utica, N. Y.....	23,000	0.40	0.08	5.0
Wilkinsburg, Pa.....	23,000	0.32	0.103	3.1
Evansville, Ind.....	22,000	0.25	0.08	3.1
Springfield, Mass.....	22,000	0.293	0.067	4.4
Cambridge, Mass.....	17,000	0.133	0.133	1.0
Yonkers, N. Y.....	15,000	0.213	0.133	1.6
Average of 30.....		0.226	0.086	2.7
Youngstown, Ohio (proposed).....	35,000	0.36	0.036	10.0

The table of existing water rates (table 1) shows the charges for water established in some of the larger cities of the United States.

It is significant that all but two of these schedules contain sliding scales and that the average spread between the highest and lowest rate is 2.7 to 1. In other words, current practice in formulating water rates conforms generally to the recommendations of the National Society.

SUMMARY

The salient points of law in Ohio which may be an aid to those who have to do with the problem of determining proper rates chargeable to large consumers are as follows:

1. That, in computing the cost of industrial water, it is not proper to include the costs of services or of equipment which do not benefit the customer in question.
2. That, in computing industrial rates (or any other rates), the cost of service as a whole must be considered and not merely those costs commonly called "out-of-pocket costs."
3. That expediency does not justify discrimination.
4. That a municipal water plant in Ohio cannot be operated at a profit and must conform to the same rules and regulations as those of a private utility with respect to rates charged.
5. That a water rate schedule containing a sliding scale with a ratio of 9 to 1 is discriminatory and cannot be sustained or justified.

It is not the purpose of this paper to discuss how water rates actually shall be computed but rather it is the purpose to set forth the above points of law which have done much to clarify the underlying principles involved in such computation. Much has been written on the subject of Industrial Water Rates and there exists today considerable differences of opinion as to how such rates properly shall be determined. It is the speaker's hope that the above paper may be helpful in clarifying some of the important problems, or principles, involved in such determinations and computation.

(Presented before the Central States Section, August 21, 1936.)

ATLANTIC CITY'S TRANSMISSION MAINS PAST AND PRESENT

BY S. N. WILLIAMS

*(Engineer, associated with Clyde Potts, Consulting
Engr., New York)*

Atlantic City is now, with the aid of the Federal Government, through its agent, the Works Progress Administration, constructing a 48-inch cast iron force main across the meadows from Pleasantville to the City.

This span across the meadows has in the time of about 50 years seen the end of the life of four pipe lines. To understand the conditions that exist a brief outline of the City's water system is necessary.

GENERAL OUTLINE OF SYSTEM

The supply is obtained by gravity from impounding reservoirs and from wells operated by deep well pumps. This supply is delivered by high lift pumps through two force mains about 5 miles in length to the City distribution system to which are connected two equalizing standpipes.

The surface supply is obtained from the watershed of Absecon Creek and tributaries. Two reservoirs impound the water and it is delivered through 9,800 feet of 60-inch pipe to the collecting basins at the pumping station in Pleasantville.

The well supply is located at the Pleasantville Pumping Station and along the 60-inch pipe line which extends to the lower impounding reservoir.

The wells in the vicinity of the pumping station discharge into the collecting basins or suction well while those along the pipe line discharge directly into this supply main.

The water so collected is picked up by high lift pumps and discharged through 30-inch lines into a 48-inch header outside the station. This header supplies a 48-inch wood stave force main and three cross-connected lines respectively of 30-, 12- and 20-inch pipe extending about 2,100 feet to the meadow edge, there to connect through a secondary header to a 48-inch cast iron force main.

The present force mains serving the City consist of two 48-inch mains. A wood stave line extends from the pumping station about 25,500 feet to the distribution system at Albany and Sunset Avenues. A cast iron line extends from the terminus of the 30-, 12- and 20-inch at the meadow edge in Pleasantville, 23,000 feet to the City side of the Beach Thoroughfare where it connects to 30- and 20-inch mains entering the central portions of the distribution system.

Two steel standpipes and the distribution pipes complete the system.

FORCE MAINS

The first main across the meadows was laid in 1882. It was 12 inches in diameter and placed about 2 feet beneath the surface of the marsh. The permanent population of the City at that time was about 6,500. This main extended from the original pumping station in Pleasantville across the meadows and the Beach Thoroughfare to the City, entering about what is now the center of the distribution system, near Mississippi Avenue.

This line for a large part of its length paralleled the present right of way of the Pennsylvania R. R., a short distance to the south. At this time the supply system was privately owned, not being purchased by the City until 1895.

Six years later in 1888 a second main was laid. It was 20 inches in diameter, cast iron, of the bell and spigot type joint and buried about $2\frac{1}{2}$ feet in the meadow. At this time the permanent population of the City had increased to about 11,000. The location of this line was in the same right of way as the first main. Evidently the natural advantages of Atlantic City as a pleasure resort were first discovered and started developing at about this time.

The third main was a 30-inch riveted steel pipe, $\frac{1}{4}$ -inch thick, laid in 1901, the top surface being about 6 inches above the surface of the salt meadow. The location of this main was within a few feet of the two prior lines. During the 13 years since the 20-inch had been installed the City had increased in population to close to 30,000.

The fourth main was a 48-inch continuous wood stave pipe $1\frac{1}{2}$ inches thick, banded with $\frac{5}{8}$ -inch wrought iron rods. The spacing of the bands was 2 to $2\frac{1}{2}$ inches center to center. It was laid in 1910 and 1911 with the axis of the pipe level with the salt marsh. By this time, with a population of 47,000, it is very likely that lack of pressure was experienced in the southwesterly portion of the City

and a different location was selected for the entrance of this main into the City. It commenced at the pumping station and paralleled the old lines for about 7,200 feet, from this point it leaves the old right of way to cross the meadow to the Pleasantville-Atlantic City Boulevard and enters the City on Albany Avenue.

The fifth main was a 48-inch cast iron pipe, bell and spigot, Class B laid in 1913 and 1914 and supported on piles and concrete bolsters, the bottom of the pipe being about 12 inches above the surface of the marsh. This line held to the same location as the 12-, 20- and 30-inch entering about the mid-section of the City which at this date had a population of 50,000.

Now the sixth main is being built across the meadows from Pleasantville to Atlantic City. It takes the same location as the wood stave which it replaces for the most of its length. It is 48-inch cast iron, bell and spigot Class B and supported as was the 48-inch cast iron line built in 1913 and 1914, i.e. on piles and concrete bolsters 12 inches above the surface of the marsh.

Out of this 54 years of experience with water mains has come proof that under conditions such as exist in the Atlantic City meadows that no particular material commonly used in pipe manufacture is safe against corrosion or decay. It is of course such experience and special tests that has given rise to the necessity of proper protection of the pipe material from water, soil and atmosphere.

EXPERIENCE WITH 12- AND 20-INCH CAST IRON MAINS

Beginning about 1902 the 12 and 20-inch cast iron lines began to cause trouble by disintegration, resulting in pieces of the pipe being blown out.

This disintegration did not occur in holes, but was the peculiar form of corrosion known as graphitization, in which the iron is leached out of the material, leaving the pipe soft and subject to easy fracture. The appearance of such pipe is often deceiving, as apparently it has received no damage, while in reality retains little of its original strength. The condition of the pipe used on the Atlantic City meadows is worse near the top than on the bottom, indicating that the deterioration is caused by some combination of vegetable matter, salt water and air. It took only about 15 years in the case of the two original cast iron mains of Atlantic City to carry the process of disintegration to a point where they were unreliable. The 20-inch line was sold for junk and the 12-inch line is still in the

meadow. I recently uncovered a section of the latter. The 48-inch cast iron line was built directly over it so it is difficult to get at. However it only took a few blows of a crow bar to put a hole in the pipe. This pipe had a soft black scale on it $\frac{1}{8}$ -inch to $\frac{1}{2}$ -inch thick. Under this the metal was soft but on the inside of the pipe the metal appears to have most of its original hardness.

Both the 12- and 20-inch pipes are still being used from the Pumping Station to the meadow edge. Here the earth is sandy with the ground water below the level of the pipe. The sand however is moist. This pipe is covered with a scale $\frac{1}{16}$ - to $\frac{1}{8}$ - inch thick, very tough, rusty in appearance and difficult to remove. Beneath the scale the pipe metal is hard and has yet to show any unreliability in carrying the pressure required of it. The 20-inch cast iron line is also similarly used between the pumping station and the meadow edge and is in good condition.

EXPERIENCE WITH STEEL PIPE

The deterioration of the 30-inch steel main was noticeable in 1906 five years after its installation and by 1912 required constant attention to keep it in service. At that time it was well established that the deterioration was in the form of pitting. The pipe walker and repair man carried a pail of wooden plugs on his inspection trips and these were used to drive into the pit holes as some of the water started to show. At that time also the record is that the pits were confined to the upper sides of the pipe, i.e., at about the marsh line. As soon as the 48-inch cast iron line was completed in 1914, the 30-inch steel line was abandoned, 13 years after its installation.

The section of this line between the Pumping Station and the meadow edge is still in service along with the 12- and 20-inch cast iron lines. This section of the steel line is in good condition. It is surface pitted to some extent after 35 years but it is my judgement that it is good for that length of time in the future.

The steel line across the meadows is today in plain sight and the deterioration has progressed until practically the entire top and upper sides are completely rusted out.

EXPERIENCE WITH WOOD STAVE PIPE

The selection of wood in 1910 for the fourth main across the salt marsh no doubt arose from the City's experience with cast iron and steel, and the possibility that this type of pipe, especially in the

48-inch size, would be comparatively easy to construct on the meadow. At the present time, 25 years after its installation, this line requires continual repair and has for several years. The critical weakness in the wood stave line is not in the bands as might be expected, but in the wood. The pipe is exposed for half its circumference and the wood is rotting as is common with any unpainted wood when exposed to the atmosphere, water, freezing and thawing. New leaks occur almost daily and the line is often out of service for repairs. The life of the wood stave as a reliable water carrier ended about 10 years ago which gives it a life of 15 years. Those sections of the wood stave that are not in the meadow are in good condition today. From the pumping station to the meadow inspection shows the wood to be firm without the slightest sign of rotting. The wrought iron bands have lost little of their original cross section. The life has gone out of the coating that originally protected the bands, but the wrought iron shows little effect of its 25 years in the ground.

EXPERIENCE WITH 48-INCH CAST IRON LINE

The experience with these several types of pipe proved conclusively that the location in the meadow and not the pipe material was at fault. None of the pipes, until the 48-inch cast iron was constructed, had any permanent foundation. They were supported by the meadow mud at varying depths. However there does not seem to have been any large amount of trouble from settlement.

The record shows that there was a foundation built for the wood stave line but it was principally for construction purposes and not for permanent bearing. The trench for the wood stave pipe was 5 feet wide and 2 feet deep. In this trench was placed a timber foundation upon which the pipe was laid. This consisted of 2-inch x 12-inch plank on both sides of the ditch with two 2-inch x 12-inch cross pieces every four feet, the whole bolted together and placed in position in the trench.

The 48-inch cast iron line supported on piles and concrete bolsters above the meadow is in practically 100 percent condition. The metal is hard and very little rust is visible. A little cleaning and painting would effectively restore what damage has come to the pipe in 22 years of service. So much for the pipe itself, it is safe above the meadow, but nevertheless the meadow will not be denied. The concrete bolsters, sound for the 12 inches above the meadow, show un-

mistakable disintegration at the meadow surface and extending below it. This is however something that can be corrected by maintenance and need not strike directly at the life of the line.

THE NEW 48-INCH CAST IRON LINE

We expect that the new 48-inch cast iron water main that is now being built will, as far as its physical condition is concerned, continue to serve the City for 100 years. What the years may bring in change of supply can hardly make obsolete the necessity of carrying the water across the meadows. Permanent construction such as this is not only done to give a long life to the work. The principle thing is, that with long life goes present security. I can think of no greater threat to the ease of those entrusted with the water supply of a City than unreliable transmission mains.

It is because of this desire for security that the new 48-inch line is being built in a rational and substantial manner. As pointed out before it replaces the wood stave which enters the City along Albany Boulevard. From the pumping station to the meadow edge no replacement of the wood stave was deemed necessary, and the new line will be connected to the wood stave at the latter point. From here the new line will parallel and replace the wood stave across the meadows to the Pleasantville-Atlantic City boulevard. Thence it will run along the edge of the Boulevard to the water way known as Great Thoroughfare. Across this water a 48-inch line of cast iron pipe was constructed a few years ago and it only remains to disconnect the woodstave at both ends of the crossing and hook up the new line and we have a continuous cast iron main. Beyond Great Thoroughfare the new cast iron main will continue along the edge of the Boulevard until Beach Thoroughfare, is reached. The crossing here has been provided for in the same manner as for Great Thoroughfare and the new main will be connected-in and end here.

The length of the line just described is about 18,300 feet all of which is in the meadow. 12,000 feet is required to cross from the meadow edge at Pleasantville to the Boulevard and the remaining 6300 feet runs along the edge of the Boulevard but still in the meadow land. In general piles will be driven in sets of two every six feet center to center of sets along the entire length of the line. Each set of piles will be capped with concrete, forming a bolster. In this way there will be two supports for each 12 foot length of pipe. The concrete bolsters, where the pipe rests upon them, are

to be shaped to the barrel of the pipe to give added bearing surface to carry the weight and also to hold the pipe from any possible lateral movement. Premoulded joint filler will be placed between the pipe and the concrete seat.

In general the meadow land across which the new line is to be built may be described as a crust 14 to 18 inches thick composed of decayed vegetable matter, roots and marsh grass with some black mud, the whole of which is not compact, but porous and spongy. Beneath this is mud slush, a slimy black material of sand and decayed vegetation of various kinds, the surface being submerged at high tide. This latter material extends down normally in the meadow about 30 feet according to the test borings we had made up to the latter part of September.

Experiences recorded on the construction of the wood stave line where piles were used at water and railroad crossings indicate that this unstable material is of much greater depths at the several water ways. However that will be disclosed as the test borings are continued.

Beneath the meadow muck there is first encountered 1 to 3 feet of transition material, that is mud and fine sand mixed. At about 34 feet below the meadow surface the fine sand is predominant. At 35 feet there is a distinct strata of coarse sand. At 36 feet the coarse sand is mixed with shell corn gravel which runs down to 42 feet. At what depth the gravel finally terminates we do not know as the tests have not been extended beyond the 42 feet depth.

The gravel affords sufficient bearing for the pipe and foundation. Each pile will be called on to carry less than 3 tons and there should be no difficulty getting sufficient bearing in the gravel. Loading tests of the pile bearing power and their resistance to horizontal thrust will be made. While it is not contemplated that the line will be subjected to any great lateral push, a determination of what its resistance is to any such force is necessary in order to determine the stability of the line. Judging from the old 48-inch line which is supported in a similar manner, no lateral movement of the line is to be feared unless conditions on the meadows change. For instance a fill of any great size on one side of the pipe line would probably force the piles over. The fills for the highways across the meadows have demonstrated many times that in some locations the heavier highway fill forces the meadow muck up several feet above its normal surface. At least one instance is known where the meadow was

raised appreciably at a distance of 200 feet from the fill that caused the displacement.

One of the problems caused by the unstable character of the meadow is the securing of the horizontal bends in the pipe line. It was well demonstrated during the construction of the wood stave line on which cast iron bends were used, that piles for bracing would not serve to prevent a bend from blowing off. The resistance of the piles to horizontal thrust is insufficient and uncertain. With sufficient penetration in the firm material below the 35 foot depth, considerable resistance could be developed, but if piles are to be used for this purpose, the greatest resistance would be secured by driving batter piles on the outside of the bend. However, with cast iron pipe the bends will be secured by the use of lugged pipe. Lugs are to be cast on the bends and on several pipe both sides of the bends. Rods running between the lugs and secured by nuts fasten the bends to the pipe line.

Bends and adjacent pipe will be anchored to the concrete bolsters by heavy metal bands and batter piles driven on the outside of the bend.

There are several small water ways to cross. At these locations it is planned to use wooden caps for carrying the pipe on the piles and the latter will be tied together with lateral and longitudinal timber members to stiffen the entire structure.

Railroad crossings are usually the most difficult obstructions to large pipe lines, but this line is the exception. The Atlantic City R. R., owned by the Reading has been abandoned since the wood stave line was constructed so that we are relieved of any problem or expense in connection therewith. The West Jersey and Seashore Electric R. R. is very actively in use but here again we are fortunate in that we are able to use the culvert built in 1911 to carry the wood stave beneath this railroad.

Up to the present, the endeavor has been to prepare for the delivery and storage of material. Pipe contracts have been awarded to two companies and pipe is coming in over the Pennsylvania R. R. The tracks pass close enough to the water line at one point to permit the pipe to be unloaded directly on the right of way. This will be used for a storage yard and pipe distributed 2500 feet both ways. Other locations will receive pipe by truck.

Pipe and all other material will be transported along the pipe line location by means of an industrial railroad running parallel thereto.

The unchanging elevation of the meadow makes unnecessary the use of engines and we intend to use man power entirely. Foundation for the track is being prepared by laying pine logs on the meadow surface. Considerable weight is carried by the meadow surface if the top crust is not broken. This is particularly true if the weight is only applied momentarily as will be the case in transporting the pipe.

(Presented before the New Jersey Section, October 24, 1936).

DETERIORATION OF PIPE AND ITS PREVENTION

BY W. R. CONARD

(*Engineer, Burlington, N. J.*)

History indicates that at first aqueducts were nothing more or less than open channels dug or constructed overland as ditches. Then came the masonry channel built to follow a uniform gradient from source of supply to point of consumption. This was followed by the closed channel or pipe, it being found that it was thus possible to transport water from one point to another without having to resort to constructing on a uniform gradient so long as the outlet was at a lower elevation than the inlet. It was then found possible by mechanical means to transport water through closed pipe from a lower to a higher elevation, and pumping water through pipe lines came in to being.

History also informs us that pipes have been made from stone, clay, wood, lead and from there to iron, steel, and other metals. Today, so far as the United States is concerned, between 85 and 95 percent of the water is transported by closed pipe lines of which by far the larger percentage is of cast iron, and in size from 2 inches to 84 inches. Pipe for individual services from the street main to and within property lines varies from $\frac{1}{2}$ - to 8-inch. Also, of the hundreds of thousands of miles of pipe line in this country probably as much as 80 percent are 12-inch diameter and less, and again of this great footage the largest amount by far is of cast iron, and the writer ventures the opinion that no one can foresee when the use of cast iron pipe will be in such reduced quantity as to be a cause for concern, by those interested in its production sale and use.

Many years ago it was recognized that, while cast iron pipe has an effective life which might be termed indefinite, probably the greatest drawback to its use was the fact that the water set up a chemical reaction which resulted in the formation of a film or scale or tuberculation which, when disturbed by an increase in the rate of flow of the water, discolored it, and from an aesthetic standpoint at least made it objectionable. To overcome this, in the 1860's a method of

applying coal tar to the surfaces was devised. For many years this appeared to overcome the trouble, until, due to methods being found to extract by-products from the tar, it was found that, because the coating was either not thick enough, or did not cover the interior surface completely, the water found its way through the tar coating, and again set up its chemical reaction. The formation of irregularities on the inner surface caused a reduction in the rate of flow, and the capacity of the pipe to deliver the amount of water required, unless the velocity was increased sufficiently to offset the friction set up by these irregularities.

In order to restore capacity some owners then commenced to have pipe lines cleaned and this method of restoration of capacity has continued up to the present, and will continue probably indefinitely. Also in order to overcome the difficulty, both users and producers began to try to find a coating which would not permit the formation of tubercles on the inside of the pipe, but largely without success until an adaptation of an old practice of using cement was thought of. Users turned to this as a possible solution. Then there was devised means of applying a heavy bituminous lining, and still other materials are being given consideration or being experimented with.

So far, the use of cement linings, bituminous linings and what not, has been confined to new pipe, though some work is being done abroad in the way of application of either a cement or a bituminous coating to pipe in place under ground and after cleaning. Little along this line has been done in this country except with pipe large enough to be entered by man, such as the recent work both with bituminous material and with cement at Newark, New Jersey, and with cement reinforced by wire mesh at New Bedford, Massachusetts. In these cases the pipes are not cast iron but steel plate, although the methods used at Newark appear as well adapted for cast iron as for steel pipe. Studies are being made of the application of a lining to pipe in place after cleaning, of the sizes too small to be entered. It is hoped that a solution will soon be found.

There have been a variety of terms used to describe the material which it has been found desirable to remove in order to reduce friction loss; such as, "deposit," "tuberculation," "corrosion," "scale," etc., and each under certain conditions is applicable. However if we look up the meaning of "corrosion" we note that it is generally speaking the least applicable. "Corrode" as defined means, "to eat away gradually, consume, disintegrate."

It has been found that usually the irregularities which cause a reduction in flow come from the water being hard and forming a "scale" or "hard film" on the interior of the pipe. This usually is difficult to remove, but fortunately causes the least friction loss. On the other hand a soft turbid water is apt to form a "mushy deposit," and this in turn is quite easily removed.

The waters which give the most trouble are those which are soft enough and active enough to start the forming of hydrates of iron. These usually take the form of "tubercles," which may be soft until the moisture leaves when they become quite hard. In some cases, due to the chemical composition of the water, they get quite hard even though saturated. In either case this tuberculation gives the greatest trouble to remove. Tuberculation is the greatest reason for cleaning pipe lines, and by the same token, causes the greatest need for the development of a relining which will prevent a recurrence of the tuberculation. Such corrosion as may have occurred in pipe lines, except in fairly rare cases, does not appear to have seriously affected the strength nor the effective life of the pipe.

(Presented before the New Jersey Section, October 24, 1936.)

PROTECTION OF DISTRIBUTION SYSTEMS BY CORRECTION OF WATER QUALITY

By H. S. HUTTON

(*Engineer, Wallace-Tiernan Co., Newark, N. J.*)

It will be the purpose of this paper to give a general and non-technical discussion of the most important methods of "correcting" the quality of water to improve its condition in the distribution system and the extent to which they are used.

We will consider corrective treatments to mean such treatments as may be used in addition to those ordinarily used to deliver a clear, potable water. Softening will be considered a primary treatment such as filtration and not a corrective treatment. Other treatments which improve the general condition of the water will be classed as corrective in addition to the usual corrective treatment for corrosion.

RESEARCH ON CORROSION

The general question of corrosion, tuberculation and incrustation of water mains has been the subject of extensive scientific researches by such authorities as Baylis, Hale, Hoover, Hopkins, Powell, Speller and others. The technical staffs of the pipe companies, water main cleaning companies and water survey companies have contributed generously to the subject. One of the outstanding contributions has been the report of the Committee on Pipe Line Co-efficients of the New England Water Works Association. This report concludes: (1) that in many cases the carrying capacity of mains is considerably less than indicated by their age alone; (2) the economic loss is large; (3) the quality of water constitutes an important factor on the rate of capacity loss; and (4) the causes of capacity loss may be classified as: tuberculation, incrustation, slime or fungus growths, and silting.

The available methods for preventing or reducing capacity loss include the use of permanent linings, corrective treatment, or use of pipe materials not subject to serious capacity loss. With most of our existing cast iron distribution systems not protected by permanent coatings, corrective treatments become of major importance.

TREATMENT WITH ALKALINE MATERIALS

The first attempt to reduce corrosion on a large scale by treatment of the water with an alkali was in Baltimore in 1920 but it was not until about 1926 that treatment of corrosive waters made much progress.

The problem is to treat the water supply in such a manner that no corrosion will take place when a fresh iron surface is exposed to the water. In order to accomplish this it is desirable to have the water saturated with calcium carbonate and preferably slightly supersaturated for a short period. After the so-called egg shell scale has been deposited in the pipe by the supersaturated water, then by keeping the water at the equilibrium point no more scale will be deposited but the deposited scale will not be dissolved.

The general practice is to add sufficient alkali to raise the pH to a point from 8.1 to 9.6 depending upon the alkalinity of the water. Lime is used very much more extensively than any other treatment, and when the calcium carbonate present in the untreated water is less than 30 p.p.m., the use of lime is almost necessary if good reduction of corrosion is desired. Above that figure, either lime or soda may be used, although the cost of the lime treatment will be much less than for the soda. Baylis gives a table estimating the cost of converting 1 p.p.m. of carbon dioxide to carbonate by lime to be about 3¢ per million gallons, while the cost for sodium hydroxide averages 19¢ and soda ash 24¢. However, it must be remembered that for each p.p.m. of carbon dioxide converted to calcium bicarbonate by lime, the hardness of the water is increased slightly more than 1 p.p.m. If we take Hudson & Buswell's estimate that the increase of 1 p.p.m. of hardness causes an expenditure for soap, etc. approximating one cent per capita per year, we find the total cost of lime treatment averages 24¢, exactly the same as soda ash and more than the 19¢ for sodium hydroxide. The latter two do not increase the hardness of the water.

EXTENT OF CORRECTIVE TREATMENT

Let us see to what extent these corrective treatments have been adopted. A brief survey of the number of cities using the various types of corrective treatment is interesting, and as might be expected, the types vary in general by sections of the country. Most of the installations are in New York, New England and along the Atlantic Seaboard.

First let us take the surface supplies with filtration. Massachusetts, Connecticut, New York, Pennsylvania, Maryland, Virginia, West Virginia, North Carolina, South Carolina and Georgia have from half a dozen to 40 each. North Carolina and Georgia seem to lead with some 40 installations. There are probably more than 250, including such large cities as Providence, Washington, Annapolis, Baltimore, Albany and Richmond. In this class we have in New Jersey the Hackensack Water Company at New Milford, Bound Brook, New Brunswick, Haledon and Trenton. A much smaller number of filter plants, about 40, use soda ash, such as Newport News and Lynchburg, Virginia; Oneonta, N. Y., Canton, N. C., Greenville, S. C., and others. Over half of these are in North and South Carolina where frequently a large volume of water goes to industries where lime is detrimental to processes. A few, including Danville, Virginia and Sewickley, Penna. use caustic soda after filtration.

Next we come to the gravity supplies without filtration that use lime. They include Bridgeport, New Rochelle, Morgantown, and of especial interest to us, Morristown and Wanaque. At the latter place lime is added for pH correction, the pH being raised to 8.8, in order to give a value of about 8.3 in the distribution system. Relatively few surface supplies without filtration use soda ash or caustic soda; Chambersburg, Pa. being in the latter class.

Next we come to the ground supplies where in certain sections we find these waters to have large amounts of carbon dioxide. There are over 25 well supplies using lime for pH correction. They include Hingham, Mass.; Salisbury, Maryland; Moundsville, West Virginia; Lexington, Va.; Marshall, Texas; Rockville Center, N. Y., and in New Jersey we have the Camden Station of New Jersey Water Co., and Lakewood, New Jersey.

Other cities, such as Newton, Mass., Ware, Mass. etc. use soda ash on their well supplies.

Summarizing this, there are some 300 plants using lime entirely or intermittently for pH correction, with 16 in New Jersey, and probably about 50 using soda ash and a half dozen using caustic soda. Another treatment which may be considered corrective is the use of recarbonation in softening plants. In the State of Ohio there are some 70 softening plants using the excess lime treatment. Virtually all of these add carbon dioxide ahead of the filters to prevent incrustations of the sand and also later excess deposition of the scale in the distribution system. Still another type of corrective treatment is

the addition of an alkali to those supplies which have been made acid by mine drainage. There are about a dozen gravity supplies in Eastern Pennsylvania using lime, soda ash and caustic soda for this purpose.

CHLORAMINE AS A CORRECTIVE MATERIAL

Heretofore in talking of corrective treatment we have thought almost exclusively in terms of proper chemical balance so we would not have corrosion of the pipe, or excess deposition of incrustants on the interior of the pipe. Recent developments in the use of ammonia and chlorine have lead us to classify the chloramine treatment also as a corrective one. First offered by Reddick & Linderman, the view that pipe tuberculation is due to biological action has been somewhat confirmed by work at Utica, N. Y., in maintaining the carrying capacity of a 12 mile pipe line by the controlled application of chlorine and ammonia. Although the iron content of this water was only 0.5 p.p.m. tuberculation was so severe that it was necessary to clean the main mechanically seven times in twelve years. Following the application of chlorine and ammonia, the carrying capacity has been maintained at the required level where previously it had lost as much as 20 per cent in a period of six months. Other cities such as Rochester, New York have noticed improvement in long pipe lines.

Crenothrix and other allied organisms have long been noted as persistent trouble-makers in water treatment plants and distribution systems. Although it was thought for many years that these organisms required the presence of iron, manganese or aluminum in their life cycle, it has since been proved that the metal is actually a waste product rather than a necessity for their life. The chief factor influencing their growth is the amount and nature of the organic matter in solution in the water. In iron bearing water the organic matter is used by the organism and the iron precipitated on the sheath where it undergoes oxidation to the insoluble ferric hydroxide. Since the growth of iron organisms and tubercle formation has been observed in pipe lines carrying water with an iron content of less than 0.3 p.p.m., a theory has been advanced and supported by a limited amount of investigation that these organisms will actually attack an iron pipe by producing acids at the point where they have attached themselves. The action of the acid causes the iron of the pipe to go into solution, and the organism in its process of metabolism removes the iron from solution and deposits it as ferric hydroxide.

Crenothrix occurs chiefly in ground waters rich in organic matter, iron salts and carbonic acid and deficient in oxygen. Its growth is favored by darkness and development can be very rapid. It causes trouble by its growth and decay in reservoirs and mains, giving rise to foul odors and tastes and by the separation and collection of ferric hydroxide is responsible for red water and clogging of distribution mains or filters. Dead and decaying crenothrix growths provide a perfect medium for bacterial growth and it is becoming increasingly evident that aftergrowths of gas forming bacteria in distribution systems are usually accompanied by growths of crenothrix or algae.

Several methods have been proposed for the control of crenothrix. Since the development of the organism is favored by low pH, the addition of lime was tried in several places but eventually discarded. At Urbana, Illinois a series of experiments were carried out employing (1) aeration, introduction of oxygen and filtration; (2) treatment with copper sulphate and (3) chlorination. While aeration and filtration seemed at first to produce satisfactory results, the gradual penetration of the crenothrix through the filter sands, strainers, underdrains and into the clear well caused the treatment to be discontinued. Copper sulphate having shortly proved ineffective, chlorination was employed in 1918 with excellent results. At Richmond, Virginia, the maintenance of a chloramine residual throughout the distribution system has materially decreased red water difficulties which were presumably caused by growths of crenothrix. Similarly, Carlsbad, New Mexico, Helena, Ark., Jonesboro, Ark., West Palm Beach, Fla., and others have used chloramines for crenothrix. In some cases such as Hickman, Ky., Murray, Ky., and West Helena, Ark., chlorine alone is used for the same purpose. There are about 25 plants using chlorine and chloramine for crenothrix control.

There are probably 50 filter plants adding ammonia after filtration for general improvement of the water in the distribution system, such as elimination of chlorinous taste, maintaining sterile water throughout the system and the elimination of dead end complaints. Among this latter I would particularly call your attention to "black water" which is caused by the decomposition of organic matter with the resulting formation of iron sulphide.

Houston, Texas, uses superchlorination and ammonia for prevention of taste, odor and control of aftergrowths in the distribution system.

Although there is no recorded instance of the use of either chlorine

or chloramine for crenothrix control in New Jersey, there are 17 supplies using chlorine and ammonia treatment to maintain a residual throughout the distribution system. Many of these supplies turned to this treatment to prevent aftergrowths of gas forming bacteria which appeared periodically in the distribution system and the suggestion is offered that crenothrix may have been in a measure responsible for the trouble.

CONCLUSIONS

Aside from the lessened depreciation, better water and better service, the improved condition of supply mains and distribution systems is taken into consideration by some State Public Service Commissions in their valuations. By keeping their systems at maximum efficiency, privately owned water companies are able to obtain a higher valuation and hence higher rates.

With better economic conditions, water consumption has materially increased and the capacity of supply mains and distribution systems is again one of importance. Together with this, increased revenues now put our water departments in a position where they are able to rehabilitate their water works—neglected to some extent by the lack of funds in recent years. Therefore it would seem worthwhile for each water works superintendent to have a survey made of the condition of his distribution system. In many cases this will show, as was brought out by the Committee of the New England Water Works Association, a far greater loss in capacity than was suspected. These conditions can be remedied in many cases by modern methods of pipe cleaning. Real progress has been made in the use of pipe linings and certainly in a large number of places corrective treatment of the water will be clearly indicated. There are some cases where exhaustive studies, such as in the case of New York City, have indicated that the cost of complete corrective treatment may not be justified. Certainly each system is a problem of its own, but with some 350 plants using corrective treatment excluding recarbonation for corrosion and a hundred more using other corrective treatments for various purposes, it is evident that many water works men are aware of the importance of the problem and are taking steps to solve it.

(Presented before the New Jersey Section, October 24, 1936.)

WATER WORKS SYSTEMS FOR FEDERAL PROJECTS

BY ELMER W. BECKER

(Engineer, Milwaukee Water Works, Milwaukee, Wis.)

Wherever people have lived together in a community, their first necessity has been to obtain an adequate source of a potable water supply. The towns built under Federal Projects have been no exception, and, therefore, the first problem of the Engineers has been to develop such a source of supply and to design a water works system to meet the requirements.

BOULDER CITY

One of the first of the recent Federal Projects requiring a source of water supply was Boulder City, Nevada, developed under the direction of the Bureau of Reclamation. Boulder City, the community which houses those connected with the gigantic Hoover Dam Project, is situated in the midst of a desert area overlooking the lake which is being created by the dam. It is some 23 miles southwest of Las Vegas, and 7 miles northwest of the Dam site proper.

Two sources of supply were available, namely: the artesian wells at Las Vegas, and the nearby Colorado River. Both of the supplies were hard and would require softening. The Colorado River supply had the additional disadvantage of containing a great amount of suspended solids.

However, due to the fact that the Las Vegas artesian well supply was 23 miles distant, careful investigation revealed that the Colorado River water would form the cheapest supply, and this source was chosen.

The great amount of suspended matter contained in the Colorado River water made necessary the use of presedimentation ahead of chemical treatment. Analyses made in the general vicinity of Boulder Canyon indicated a suspended solids content of as low as 395, reaching a maximum of 59,400 p.p.m. The mean suspended solids content was slightly over 6000 p.p.m.

The original studies made on the water indicated that the softening

plant could economically handle a water which contained a suspended solids content not to exceed 250 p.p.m. under average conditions.

Therefore, it was necessary to divide the Boulder City water works system into two distinct parts: the pretreatment works situated on the banks of the river a mile below the Dam site, and the softening plant at Boulder City.

The pretreatment works consists of the river intake, the presedimentation clarifier, sludge pumps, the 30,000 gallons sump pump, and the high head pumps which deliver the water to the softening plant at Boulder City.

As the water arrives at the Boulder City plant, it is discharged through an aerator on the top of the 100,000 gallon equalizing tank and from there flows by gravity to the nearby softening plant.

The softening plant is designed to soften the Colorado River water by a modified form of excess lime-soda ash treatment.

More recent Federal Projects requiring a source of water supply and a water works system are the towns being constructed by the Division of Suburban Resettlement, Resettlement Administration. These were four in number, now reduced to three, and their size varied from 750 to 1000 housing units. They are located as follows: Greenbrook near Bound Brook, New Jersey; Greenbelt near Berwyn, Maryland and about 5 miles northeast of Washington, D. C.; Greenhills near Cincinnati, Ohio; and Greendale in Milwaukee County, Wisconsin, about 5 miles southwest of the City of Milwaukee corporate limits.

GREENBROOK

It was intended that Greenbrook, New Jersey, should be one of the first Suburban Resettlement Projects to be constructed and here the problem was not only to obtain an adequate potable supply, but also to obtain an unchartered supply or to obtain a supply from a water company having charter rights on a quantity of water more than sufficient to meet their own requirements. The laws of the State of New Jersey require that all communities obtain their water supplies by charter rights through the New Jersey Water Conservation Board.

The Bound Brook Water Company, adjacent to the Greenbrook Project, had all water rights within the township and did not have a sufficient quantity to supply Greenbrook.

Therefore, it was necessary to purchase a supply outside of the

County from the Elizabeth Town Water Company which has the charter rights on the Milestone River Supply. This plant produces a filtered water and has a capacity of 10,000,000 gallons per day, but is using only 3,000,000 gallons. Greenbrook would require 300,000 gallons per day.

By agreement, the Elizabeth Town Water Company was to lay $\frac{1}{2}$ mile of 16-inch diameter feeder main to the County line, install a master meter at this point, and deliver water at the wholesale rate of 9 cents per 1000 gallons.

The Greenbrook Administration was to connect at this point and lay about 3 miles of 12-inch diameter feeder main to the project pumping station and 500,000 gallon capacity elevated tank, from where the water was to be distributed throughout the town.

GREENBELT

The second Suburban Resettlement project, called Greenbelt and located near Washington, D. C., had three possible sources of supply under consideration, as follows:

(1) underground supply from wells, (2) surface water from Beaver Creek, and (3) connection to the Washington Suburban Sanitary Commission with intake from the Anacostia River, a branch of the Potomac River. The intake, filtration works, and pumping station of the last named are located at Burnt Mills, Maryland, a little more than 2 miles from the project.

The Greenbelt development lies on what is known as the Coastal plain, which is very uncertain as a source of underground water supply. Wells have been drilled in the immediate neighborhood to depths of about 600 feet and have produced quantities varying from 40 to 100 g.p.m. The uncertainty and expense as well as the limitation of this source of supply removed it from further consideration.

Beaver Dam Creek flowing through the United States Department of Agricultural Experimental Farm has a drainage area of approximately 12 square miles. The normal flow of this creek at the point considered for intake is about 4 second feet. Three-fourths of this flow is required further down-stream as dilution for the effluent of the Farm's sewage treatment plant. This leaves an available supply of one second foot or approximately 650,000 gallons per day, which is more than enough for the present town development.

In times of drought, such as was experienced in 1931, there would be no water available from the creek and any expansion of the

Project would find this supply totally inadequate. In either case, a proposed artificial lake would have to be used as a supplemental reservoir at times as the sole source of supply.

Both Beaver Dam Creek and the lake would require the most complete chemical treatment and filtration necessitating the continuous attendance of a technically trained operator.

Because of the uncertainty in time of drought and the known insufficiency in the case of further expansion of the project, this source of supply was dropped from further consideration.

The Washington Suburban Sanitary Commission's water district is immediately adjacent to the project and the future extension of their district would probably include the entire development. Their supply of water from the Anacostia River is ample for both present and future needs and therefore it was chosen to be the logical source of supply for the Greenbelt Project.

The water will be transported from the Commission's pumping plant and filtration works at Burnt Mills, Maryland, through 12,000 feet of 16-inch cast iron feeder main to a 2,000,000 gallon capacity standpipe to be erected on the Greenbelt Project, from where it will be distributed throughout the town.

The third Suburban Resettlement Project called Greenhills and located near Cincinnati, Ohio, also considered three possible sources of supply, namely: (1) connection to the City of Cincinnati distribution system; (2) connection to the water works system of several smaller cities in the vicinity; or (3) developing a well supply.

GREENHILLS

Greenhills is located in Hamilton County, a considerable portion of which is served by mains laid under the Ohio county sanitary district law by assessments and is operated by the City of Cincinnati under an agreement which does not expire until October 1944.

Therefore, a water supply will be developed by drilling three 12-inch diameter wells to a depth of about 100 feet; each is expected to produce a minimum of 450 g.p.m. with a maximum drawdown of 20 feet.

The water will be transported from the wells through a 16-inch diameter, $\frac{1}{4}$ -inch steel plate pipe with bituminous spun lining, a distance of 5 miles to Greenhills. This water will be aerated, softened, filtered and chlorinated; it will be pumped from elevation 560 to 945 by motor driven centrifugal pumps to a standpipe of

1,500,000 gallon capacity from where the water will be distributed throughout the town.

GREENDALE

The fourth Suburban Resettlement Project, called Greendale and located in Milwaukee County, Wisconsin, considered two possible sources of supply, namely: (1) by connection to the City of Milwaukee Water Works; or (2) by developing a deep artesian well supply on the project site.

An application requesting permission for a feeder main connection was submitted to the Common Council of the City of Milwaukee. This request was refused. A study of comparative costs showed that a complete water works system with a 16-inch diameter feeder main connection to Milwaukee, approximately $5\frac{1}{2}$ miles long, would cost \$161,000 more than a system supplied from deep artesian wells drilled on the site; the City of Milwaukee supply costing \$437,000 and the deep artesian well supply costing \$276,000. Furthermore, the cost of water to the consumer from the Milwaukee supply would be 31.3 cents per 1000 gallons and from the well supply would be 22.1 cents per 1000 gallons.

Therefore, the well supply was chosen. Two deep artesian wells will be drilled to a depth of about 1800 feet to the Mt. Simon or Potsdam sandstone, similar to the Wauwatosa wells. The water produced from the wells should be satisfactory for all purposes except for washing and heating because it will have a hardness varying from 480 to 615 p.p.m. This hardness will be reduced by a central Municipal softening plant.

The water works system is designed for a population of 4300 and is based on a yearly average consumption of 75 gallons per capita per day. It will be capable of delivering a peak demand of 2000 g.p.m.

The system consists of two deep artesian wells with a pumping station over each well (cross connected with a 10-inch diameter cast iron main), a softening plant, a 400,000 gallon capacity elevated steel tank, and distribution system.

Each of the pumping stations will contain an electrically driven deep well turbine pump and an electrically driven centrifugal pump, each capable of delivering 1000 g.p.m. The pumps at the south station will be provided with alternate gasoline power for operation during electrical power failures. The south station will also contain the softening equipment and adjacent to it will be ground storage of 100,000 gallons capacity with an aerator overhead.

Treatment will consist of aeration, sedimentation, and softening.

Softening will be effected by the zeolite or base exchange method, the equipment consisting of three fully automatic vertical type units. All water for uses other than for fire fighting purposes will be softened to 103 p.p.m.

The elevated steel tank, 400,000 gallon capacity, 66 feet to the bottom, will provide static pressures throughout the town varying from 40 to 85 pounds.

The distribution system will consist of 12-inch, 8-inch, 6-inch and 4-inch cast iron mains lined with bitumastic enamel. Hydrants will be spaced not over 400 feet apart and none connected to 4-inch mains. There is a 12-inch main laid from each pumping station to the elevated tank, these mains are to be cross connected with a 12-inch main through the business section of the town. The distribution system is well cross connected and gated so that not more than two hydrants will be out of service for repairs at one time.

Services are soft copper $\frac{3}{4}$ -inch and 1-inch diameter. Branches to public and commercial buildings are cast iron.

During normal operation either one of the deep well turbine pumps will pump water through the aerator discharging to the ground storage tank at the south station. The booster pump at south station will draw water from the ground storage tank, pump it through the softening plant into the distribution system and elevated tank.

During time of emergency when fighting a fire, the combination of either deep well turbine pump and either booster pump will pump directly to the distribution system and by-pass the softening plant.

It is interesting to note that of the five federal projects here considered, all except one studied the possibility of securing an underground supply but only two of them actually will use this source of supply; the other three projects will obtain their water from surface sources or from rivers.

Furthermore, it is interesting to note that three of the projects will construct their own intake works or pumping stations, while two projects will purchase their water supply from an established water company.

(Presented before the Wisconsin Section, October 7, 1936.)

PENSION SYSTEMS BASED ON INSURANCE

BY MERRILL TAFT

(*Traveler's Insurance Company, Milwaukee, Wisconsin*)

For the past seven years we here in the United States have been subjected to the stresses and the strains of economic troubles, the repercussions of which are still largely with us. We have seen the life savings of hundreds of thousands snuffed out, dissipated, vanished into thin air.

All about us we see elderly people who have lost their all, in one way or another, and with it their opportunities to recoup. On account of age, they cannot come back. Theirs is a very real and perplexing problem.

Again, on the other hand, we see younger people whose philosophy of life is "Eat, drink and be merry and make no provision for the future." They base this program of life on conclusions drawn upon the experiences of these elderly people who have worked, slaved and saved and now have nothing.

Now, of course, some lessons are to be gained from the experiences we have been through. We cannot, under any circumstances, accept this philosophy of defeatism. We must rebuild instead and when we rebuild, it must be upon more substantial and lasting foundations. *In a word, we must continue our search for security.*

Many corporations and institutions have recognized this need for security and have made available to their employees plans to provide for their future. Within the last year or so our Federal Government has also realized the need for Social Security and has made some very definite commitments along that line. As a result there was drafted the Social Security Act of 1935, which is to become effective on January 1, 1937, and provides, among other things, a Pension Plan for all employees who are, at that time, aged 60 or under, with certain groups excepted. Among those groups that are excepted from the Federal Plan are employees of the State or political subdivision thereof. However, the employees of these groups are quite naturally, just as much interested in security as any other

group of employees. At the present time, many of our municipalities or departments of municipalities have established Pension Plans and many more are giving serious consideration to this all important problem.

Because there is no general plan for Water Works employees I would like to discuss with you briefly the problem of these employees and suggest a possible solution.

In running any business, it is necessary, as you known, to provide for depreciation and obsolescence in connection with the physical properties. Isn't it as essential that a business provide reserves for the replacement of man power, the depreciation of which is inevitable? If through misfortune, lack of foresight, thrift or investment ability, separation from his job virtually amounts to kicking the employee into the street upon retirement, the job of retiring him is, indeed, a tough one. In any case, it is difficult to retire a faithful old employee by cutting him off the payroll.

It would appear, therefore, that inasmuch as the employees of the Water Works Department are not eligible to participate in the Federal Pension Plan, that the individual departments themselves must see to it that a private Pension Plan is established for the benefit of employees.

At first thought, you might feel that there would be some disadvantages in using a private plan as against using the Government Plan, but after a little careful analysis, I think you will agree that this is not the case.

(A) First of all, the Federal Pension Plan specifically limits the amount of retirement income an employee may have, inasmuch as the maximum contribution by both the employer and employee is 3 percent of employees wages and this maximum contribution is not reached until 1949. Furthermore, the maximum benefit under the Security Act is \$85.00 per month and this would apply only where an employee, now age 20, earning a minimum salary of \$250.00 per month for the full 45 years contributed in each of the 45 years. Therefore, men in their 40's and 50's could not expect to have an adequate income at retirement age.

Under a private plan the amount of the pension is determined by the amount the employee wishes to save, plus any amount that the employer may wish to contribute—this advantage of flexibility cannot be overestimated.

(B) In the second place, in the event of the death of an employee,

under the Government Pension Plan the employee's estate receives a sum equal to only 3.5 percent of his total taxable wages up to the time of his death (\$200 per month—10 years—\$840.00). This is a very unsatisfactory remainder, especially is this true if he leaves a wife and family behind him.

Under the private plan, provision may be made to continue all or a portion of the employees salary to his family for one or more years, depending upon the number of units he sets up for himself. I think you will agree that this is a material advantage.

(C) Furthermore, the Government Plan has no provision for cash surrender values, either to the employer or to the employee.

In the case of the private plan there are cash values available after the second year. In the later years the cash values are substantially larger than the total deposits made. Over the years, this liquid reserve fund might be of considerable assistance in many cases to both employee and employer. This, I would consider a very outstanding advantage of the private plan.

Further advantages of the private plan could be cited, but I believe you can already see that by adopting this method, you would be offering your employees many benefits that they would not get under the Government Plan.

Now, in the past, many corporations have tried to handle their employee plans themselves. By this I mean, that they have set up special reserves out of their earnings plus contributions from the employees, to take care of benefits for an employees family in the event of his death or for an employees retirement if he outlives his usefulness. In only a few instances has this method worked out satisfactorily. Some few large corporations still operate their own plans—the large majority have selected one of the large insurance companies to handle this problem for them. Within the last year or so many companies have transferred their own company plans to an insurance company plan—I might mention two in particular, the United States Steel Corporation, and the Socony Vacuum Company.

In selecting an insurance company to set up for you a plan that will satisfactorily meet your requirements as employers, and also those of your employees, considerable scrutiny be given to the financial stability of that company, and to that company's experience and ability in handling these problems. A large number of employers have arranged a plan for their employees, called a Salary Allotment Plan, which is truly American in its scope since it permits

a man to voluntarily arrange to take care of his dependents in event of his premature death and his own old age when he outlives his usefulness. This plan was developed after many experiments and years of experience. Early in the development of the idea, the *advantages* of the plan were offered to the salaried employees of the Travelers. Now they are available to the employees of other firms and organizations. The installation of the plan does not compel employees to participate in it, but leaves them every freedom of choice they had before such a plan was adopted. There is no stipulated percentage of employees who have to come in to make the plan operative. The amount of bookkeeping necessitated for the smooth functioning of the monthly allotment plan is very small—in a very short time the system becomes practically automatic.

In summing up the advantage of the plan, it is fair to say that one of three things is going to happen to every present employee of your organization.

First—The employee is going to leave and work for someone else.

In that event, your problem no longer exists.

Second—The employee is going to meet with an untimely or unexpected death. In this event, the monthly allotment plan will continue the employees salary, or an essential portion of it, on to his dependents for one or more years, thus relieving you of a serious problem.

Third—The employee is going to arrive at an age when his services are no longer profitable to the department. In this event, the plan will retire the employee on a substantial monthly income. This again relieves you of a very perplexing problem—namely, that of getting rid of an employee who is a liability to your organization.

In order to assist an employee in making these provisions for himself and his family, many employers have contributed a certain percentage of the necessary monthly savings. The amount of this contribution is usually based upon some such factor as Age of the employee, length of service, or his monthly income. In any event, your contribution will assure the participation in the plan by all or at least the majority of your employees.

For the purpose of illustration, I would like to demonstrate how this plan would operate taking the case of an employee, age 30 drawing a salary of \$150.00 per month. Let's say that he is married and there are children.

He decides that he would like to have, as a minimum, \$100.00 per month for life beginning at the age of 65—but realizing that he may not live to age 65, and that he might be taken from his family unexpectedly—he arranges through our plan, to provide his family with an income of \$100.00 per month for a period of 10 years following his death—because, after all, it is his family as long as they live, not as long as he lives.

To accomplish his objective, it would be necessary for him to save \$22.80 per month. This, of course, may be more than he can save right now—but maybe he can put half of the plan into operation or a smaller amount now and increase the benefits later—or, perhaps, you, as employers, can assist him by contributing as much of the necessary savings as you see fit.

Should it become necessary through some unforeseen circumstances to terminate the savings before the employee reaches 65, there are several options available to the employee. For example, if this should happen at the end of 5 years: (1) he may withdraw his portion of the cash reserve; or (2) he may retain a paid up unit—which would pay his family \$160.00 if he were to die before the age 65—and if he lives to age 65, pay him \$160.00 in cash; or (3) he may arrange to continue to his family the full protection of the plan for a period of 9 years. Naturally, the longer the plan is continued, the greater the benefits become. The plan is designed to meet satisfactorily any and all emergencies as they may arise. Should he leave your employment he can arrange to continue the plan elsewhere on the same basis.

In this brief talk, I have only attempted to remind you of *your* problem, as employers, and suggest to you a medium through which the problem may be solved. If you would like further information about this plan as it would be applied to your own organization, the Travelers organization will be glad to cooperate with you.

(Presented before the Wisconsin Section, October 6, 1936.)

WATER WORKS ACCOUNTING AND FINANCE PRACTICE

BY JACOB SCHWARTZ

(Counsellor at Law)

(New Jersey Public Service Commission)

(Newark, N. J.)

Waterworks operators are generally interested in maintaining a fine set of records with the limitation, of course, that the amount expended for maintenance of such records should not be out of proportion to their ultimate value. There are several distinct major sets of records in a waterworks organization. I will attempt to review these generally, laying more particular emphasis on fixed property records and the value of statistics.

CUSTOMERS' ACCOUNTS

The customers' accounts department's main function is to prepare neat looking, understandable customers' bills promptly, accurately and economically, and to maintain proper office records of billings and payments so that billing statistics may be compiled and the status of individual customers' accounts made available at all times. Accurate and legible bills, together with prompt and accurate posting of payments, reduces customer complaints and is conducive to obtaining the respect and good will of your customers. Those in charge of this department should not underestimate the value of their work and should familiarize themselves with reports on new billing methods and equipment. It may also be timely to suggest that customers' accounts records represent a field for possible reduction of accounting costs because of the large volume of customers' accounting.

STOREROOM AND PURCHASING

A study of purchasing and storeroom practices may frequently lead to substantial economies. The officer in charge of purchasing

and storerooms accounts should be familiar with the best method of handling and storing materials and supplies, as well as most modern practices to improve systems of purchasing, controlling and issuing stock. The activities of the officer in charge of this department should also embrace other details usually associated with storeroom functions, such as methods of salvaging and disposing of used equipment, reducing used materials to scrap, reclamation of used materials, etc.

FIXED CAPITAL RECORDS

Of a large number of miscellaneous general records such as accounts payable records, payroll records, tax insurance, interest and dividend records, the general journals and ledgers contain an important division of the records. As you know, the bookkeepers' records of property, or fixed capital, is a listing of the charges to construction work orders. This frequently bears little descriptive relation to the property as seen in the field. A fixed property record system, if properly maintained, bridges the gap between the dollar records in the general ledger and an inventory of the property in the field as an engineer would see it. Let us dwell for a few moments on the fixed property record system and its uses.

Some waterworks executives who feel that existing classifications of accounts are unduly burdensome may be hard to convince that even greater detail is in the long run advantageous and economical. A uniform classification of accounts is, of course, the backbone of a fixed property record system. We are concerned now, not merely with satisfaction in classifying costs in accordance with major divisions corresponding to fixed capital account classification, but in advocating the recording of fixed capital data within the particular accounts in sufficient detail to make your system a thing of material value rather than a cold list of financial transactions.

RELATIONSHIP OF ACCOUNTANT AND ENGINEER

It might not be amiss to digress for a moment upon the relationship of the accountant and engineer in connection with this subject. One of the main functions of an engineer employed by a utility is to work out in detail the best as well as the most economical method of supplying the present and prospective needs of the properties. In order to determine the proper course to pursue, he must be able to prepare accurate estimates of the cost of the different possible

methods of solving the problem at hand, and determine with certainty the best solution. Accurate estimates are dependent upon the availability of dependable cost records, frequently unit costs, actually experienced in similar projects. Consequently, the engineer would request that the accountant assist him by keeping his records in such a manner that the desired information may be available.

When the engineer can tell clearly what he wants and demonstrate the necessity for the information, the accountant should cooperate to supply the same, if after determining the extra labor required to record such costs and considering their advantages, it appears to be of ultimate advantage to their common principle, to record the costs in the desired detail.

Of course, all the cooperation must not be on the side of the accountant, the construction engineer should be required to familiarize himself with details of fixed property accounts and all reports to accounting division should adhere rigidly to the adopted system. Reference in the record to filed blueprints and sketches is not only desirable but important.

CONTRACT WORK

Now, just a word as to the importance of properly recording contract work. This work is often paid for, particularly in lump sum contracts, without due regard to the component units entering into the completed property. Itemized costs frequently become lost in sum totals to such an extent that determination of accurate unit costs is impossible. This same condition would obtain in the case of cost-plus contracts if the contractor is not required to report his costs in accordance with the company's established fixed property record system. Every effort must be made by cooperation of the company's engineering and accounting division with contractor to obtain the desired information in the necessary detail in order to avoid a breakdown of the fixed property record system.

RATE INVESTIGATIONS

Let us consider the advantage of accurate detailed fixed property records in a rate investigation. The proposition may appear academic and one not requiring proof; however, a reiteration of some of the factors involved may not be amiss. The discussion of this topic is, of course, not to be considered an argument for adoption of

book cost as the sole measure of value of a utility property. A proper record system provides perhaps the best base for the fixation of the value of a property. Much has been said in criticism of the reproduction cost theory due to wide latitude of opinion evidence upon which it rests as well as its speculations, and uncertainties. We must not lose sight of the fact that these same criticisms were leveled at book values in the earlier regulatory decisions, due in the main to the fact that the books did not disclose an accurate picture of the company's fixed assets. Had the records been in better shape, the trend of the opinions might have been along different lines. The task confronting regulatory bodies and the courts in wading through a maze of reconstructed cost data in order to arrive at a value has by no means been an easy one. With the availability of a fixed property record system and by the use of known factors or indices frequently obtainable from the record system itself, valuation of a property at price levels consistent with different periods of time is considerably simplified. The intelligent recording of plant data will tend to eliminate in a large measure wrangling and costly litigation with respect to facts as distinguished from legal principles.

OVERHEAD

Reference should be made to the importance of providing for the proper treatment of overhead or indirect costs in a fixed property record system. If a consulting engineer is retained for a particular job, there is no apparent difficulty in accounting for his fees. The problem is to allocate properly the working time of members of your own organization who are occupied with a wide variety of work in the commercial, operating and construction divisions. If the records are to be accurate, some effort must be made which is more satisfactory than end of year lump sum departmental estimates for division of working time. A desirable plan involves filling out of daily time allocation sheets by all engineers, superintendents and departmental heads. Provisions should also be made for charging to construction work use of tools, repairs of construction equipment, and a portion of store and purchasing expense. The incorporation in the record system of the element of time will aid materially in determination of such other indirect expense as interest, taxes during construction, and insurance. Indirect costs generally represent a sizeable percent of the fixed assets, and their accurate fixation is not infrequently a determining factor in a rate investigation.

RETIREMENTS

The treatment of retirements has frequently been challenged in determination of value from the books of account. We must not lose sight of the fact that property is not retired in the same manner in which it is installed. Individual items or units are removed from service which were originally installed with others. Any system of recording fixed capital which does not provide for the earmarking of units introduces an estimate at retirement. The question then suggests itself, why not write the item in at estimated cost if we are to retire it in that way? It is inescapable that only by a proper record system can we maintain the integrity of the plant and property accounts in accordance with the avowed intention at the time the system of classified accounts was installed.

INSURANCE

Let us now consider the value of the fixed property record system from the view point of insurance. Care should be exercised to know that insurable property is adequately covered, that the values of foundations and similar property are excluded from coverage and that the insurable values are neither too high nor too low. It is also important that insurance be taken out or promptly cancelled when property is added or retired. In addition, detailed records of insurable property should be available for prompt and accurate substantiation of the full claim in the event of a loss.

Values shown in the record system are naturally the original costs of the property at the time of acquisition or installation. It is apparent that original cost and insurable value as of the time of execution of insurance contracts are not necessarily the same. Unreasonably high insurable values result in excessive premiums. On the other hand, undervaluation will not provide sufficient coverage in the event of a loss. The original cost as it appears on the record system provides an accurate base for determining insurable values by application of suitable price trend factor.

When a loss occurs, we realize the importance of availability of property records to adequately set up and substantiate the claim. The record system is an excellent source from which we can obtain in sufficient detail an inventory of all items in existence prior to the loss. For only with such complete data can we properly establish the maximum loss sustained.

TAXATION

Methods of taxation vary considerably. The detail of the fixed property record system would necessarily have to be moulded to fit the particular method of levying taxes. Good property records should include a systematic segregation of taxable property into units, sections, tax districts or political sub-divisions, together with the usual descriptive and cost data. With such records the company is in a better position to demonstrate any inequality in the taxes and save not only in its tax bill but in the cost of proving what it considers a reasonable and fair assessment of its taxable property. Additions and retirements of property subject to taxation naturally affect the tax bill. It is most important to have accurate records of such changes to insure a fair assessment and to provide tax officials with accurate data upon which they must necessarily be dependent in determining the proper tax to be levied. This is an important feature for waterworks since the personal property tax is based upon value of the property and not the gross receipts as is the case in other types of utilities.*

The cost of maintaining tax detail in connection with your fixed property record system undoubtedly will be less in the long run than the cost of making inspections and special studies for this purpose at stated intervals. In addition to advantage and uses of a fixed property record system previously discussed, accurate data are readily available for cost of service studies, preparation of income tax returns, applications to regulatory bodies for issuance of securities, as well as for preparation of all sorts of financial and statistical reports.

STATISTICS

We now come to another important chap whose duty it is to interpret a large volume of records; for want of a better title we'll call him the statistician. In a small waterworks he is frequently the superintendent who is generally expected to be a sort of combination magician and jack of all trades. The statistician's job is selecting what is most vital out of the mass of data in the records and giving the proper prominence to the most significant results. Interpretation of figures is probably just as important as their correct compilation, for figures by themselves are of little value unless related to other factors which give them real significance.

*EDITOR'S NOTE. The method of assessment varies in the different states.

The problems confronting the executive of today, with organizations consisting of hundreds of employees and millions of dollars worth of property, are different from those which presented themselves to the executives of days gone by. Today it is frequently physically impossible for him to be personally well acquainted with more than a reasonably small number of his employees, or to keep personally posted with all operating details. He must therefore resort to other means to keep in touch with conditions in the system under his control. Statistics, tabulations and reports aid him materially in this respect. The history of the business is recorded by the accounting department. If, however, the historical record is limited to financial transactions only, the picture presented is incomplete, for the financial records do not, unless properly related to operating records, present the data in which the management is really interested. For example, the cost of pumping may show a gross increase; however, if the cost per million gallons pumped is decreasing, the management would not be disturbed. For it is appreciated that if the cost per million gallons is decreasing while the gross cost of pumping is increasing, a healthy condition is disclosed. On the other hand, if there is an increase in the gross pumping cost as well as the cost per million gallons, then the management is interested in correcting the conditions which produce such results. To put it briefly, the management needs statistics prepared in a manner which will enable it to correctly interpret operating results. The accountant should develop his statement in a way that will be most valuable to those who are responsible for making decisions and determining the policy of the organization. The management should similarly assist the accounting division by indicating the purpose of studies or compilations which it has requested and which will place the accounting department in a better position to make up its statements and reports intelligently.

The trend in recent years towards centralized management places greater emphasis upon the value of reports and statistics since major operating policies are frequently determined long distances from the scene of operations. The accountant must therefore be an analyst as well as a financial historian, and should possess at least general knowledge of the operating conditions of the particular property. His efforts cannot be confined to simple recording of facts, but he must analyze, interpret and condense results in such a manner that a busy executive may be able to get the important results quickly without wading through a mass of detail. It is

obvious that the supporting details must be available, for if the analysis or results are challenged, then the supporting details become a matter of vital importance.

SUMMARY

Records which are not compulsory should be judged to an extent by performance; they should earn their salt. However, in discussions relating to the probability of benefits or savings accruing from the establishment of a new set of records, we are frequently confronted with arguments similar to the old quibble of "Which came first, the hen or the egg?" It is undeniable that the establishment and maintenance of a good system of records involves substantial cash outlays; however, without these same records, it is frequently difficult to determine how and where possible economies far offsetting the cost of the records can be effected. In closing it should be noted that good records also have an important intangible value in building good will by helping to down that persisting old "bogey" that there is something inherently iniquitous and tricky about utility accounting practices.

(Presented before the New Jersey Section, October 24, 1936.)

DIESEL ENGINES IN WATER WORKS PRACTICE

BY W. E. WECHTER

(Asst. Manager Oil and Gas Engine Div.)

(Worthington Pump and Machinery Corporation)

(New York, N. Y.)

On September 10, 1936 the ten-ton flying boat "Zephyr" landed at the Pan-American Airways marine base at Port Washington, N. Y. This Dornier monoplane, manned by four Germans, had completed a 2390 mile, non-stop flight from the Azores, in a little over 22 hours. This ship, the forerunner of a fleet of similar ones which will soon begin a scheduled service over the South Atlantic route, is diesel powered.

The round trips of the zeppelin "Hindenburg" have become so commonplace that we scarcely note the news items which tell of another safe ocean crossing. This giant airship is also powered by diesel engines.

If we lived along the route of the Santa Fe Railroad we would probably be thrilled to see "The Chief," the new streamline train of the Chicago-Los Angeles division, racing along at speeds well up to 100 miles per hour on its scheduled trip to the Pacific Coast. This train is pulled by a 3600 horsepower diesel locomotive. It makes this 2228 mile trip in 40 hours, several hours faster than any other train, and requires only $2\frac{1}{2}$ gallons of fuel per mile with its full load of pullman cars and coaches.

A few years ago, the term "diesel engine" was unfamiliar to most of us. Recently, however, we have seen it used so frequently in our magazines and newspapers that it has become quite common and has lost much of its mystery. Boats from the largest battleships to small two-man fishing dories; tractors, from those which pull the great wheat combines to the sizes used on the small farm; trains, from the transcontinental express to the side-track switcher; trucks, large and small; busses, passenger cars, airplanes, all these forms of transportation and utility are rapidly approving the diesel engine. It is the achievements in these fields which have been largely responsible for focusing public attention on this newest form of power.

All of us, who are in any way connected with the diesel industry, are encouraged by this growing popularity.

HISTORY OF DIESEL DEVELOPMENT

The diesel engine is not new. In the year 1680 a man named Hughs developed and built an internal combustion engine. It was not a success and was evidently not encouraging to this early experimenter as we find no further reference to it. During the following years there were many other attempts to perfect this type of prime mover, but it was not until 1868 that Otto, a German merchant, developed a four stroke cycle which bears his name and built a successful engine to operate on this principle.

The sound theory which was advanced by Otto is still the basis of our modern gasoline engine.

During the 1880's Gustave Schmidt, an Austrian engineer, and George Brayton, an American, did some experimenting on internal combustion engines in which oil was used as fuel. However, the first man to achieve success in this work was Dr. Rudolph Diesel, a German. In 1893 he published a pamphlet entitled "Theory and Construction of a Rational Heat Engine." In this he described a combustion cycle which was new and on which he was able to obtain an international patent that same year. This diesel cycle, as it soon came to be known, was an outstanding success. European engine builders were prompt to begin manufacture of engines in which this cycle was used. In 1897 the first practical diesel engine was built at Augsburg, and that same year it was exhibited at the power exposition in Leipzig.

Adolphus Busch, the St. Louis brewer, attended the Leipzig Fair that year and became so interested in this new engine that he obtained the manufacturing rights in America. He brought back working plans, and within a few years he and his engineers were supervising the building of American diesel engines. So you see this present popular type of engine is really not new and has been established in American power plants for well over thirty years.

The question naturally arises why greater emphasis was not placed on the diesel engine until during recent years, especially in the United States. I believe this question can be readily answered when we consider these facts:

First,—The economy of the diesel design which is its outstanding merit was not so important until recently. Our large industrial

centers built originally where water power was available were not concerned with the lowering of power costs; coal was plentiful and cheap for those factories not fortunate enough to have water power; and in the smaller communities gas and kerosene furnished most of our lights; and the old fashioned hand pump and reciprocating steam pump supplied most of our water. Our modern forms of transportation were still in their infancy. In short, the need for a definitely economical power plant had not been felt.

Second,—As the diesel engine operates with higher combustion pressures and requires greater strength and rigidity in design, the early engines were heavy and costly. Metallurgy, foundry practice and machine design had not advanced to the point where we were able to obtain these necessary qualities combined with lighter weights and lower costs. However, the increasing demand for additional power in all fields of industry and transportation, together with higher fuel costs and advanced machine design experience, have all had their share in the progressive development of the modern diesel engine.

So, today, we find a definite demand for the economy and reliability of the diesel engine in every field where power is important.

It is but natural to assume that improvements in engine design and construction will continue to be made. We believe, however, that this modern engine has proved itself in every way, and has reached the point where it is not only the most economical and efficient source of power, but has reliability and endurance, which are the equal and in many cases the superior of other prime movers.

POWER FOR PUMPS

We are all familiar with the advances made in the mechanics of water pumping. From the simple steam pump through the compound and triple expansion pumping engines to the modern centrifugal with its present high degree of efficiency and reliability. As far as the pump unit itself is concerned it is doubtful if further advances will be rapid or important, at least in the near future. With pump efficiencies of from 80 to well over 90 percent, depending on size of equipment involved, there is little room for betterment. We must, therefore, look to the drivers required to operate these units if we are to go still further forward in the art of water pumping.

While steam turbines have been a practical and reliable form of pump driver, some new installations will be made when local condi-

tions are particularly well suited to them. During recent years, however, the electric motor has been in the ascendency and from a straight engineering standpoint this type of drive has been acceptable.

However, while purchased electric power has been convenient and, in the majority of cases, quite reliable, the cost of this source of energy has given the waterworks superintendent and the community officials concern.

While the diesel engine is not a panacea for this condition, it has assisted in so many typical locations that it warrants serious and thorough investigation.

DIESEL ENGINES IN WATER WORKS

Diesel engines are employed in the modern waterworks in two ways, either as a prime mover directly connected to the pump or to drive a generator which furnishes electric energy for pump motors.

The direct connected engine-pump unit has the advantage of lower first cost and higher efficiency due to the reduction in electrical losses in generator, switchboard and motor. The engine generator unit has greater flexibility and is more easily adapted to many existing stations. Hundreds of installations of both types have been made in the United States during the last twenty years.

The majority of diesel-centrifugal units use speed increasing or "step-up" gears between the engine and pump. One of the latest installations of this type made is in the plant of the Pennichuck Water Works, a private water company at Nashua, N. H. This unit, which was placed in service in March 1935, has a 250 H. P., 400 r.p.m. diesel engine, driving a 10-inch single stage centrifugal pump at 1350 r.p.m. through a gear set.

Points taken from the acceptance test runs of this unit show the results given in table 1.

Incidentally, the fuel consumption guarantee which was made on this engine at $\frac{3}{4}$ load was 0.42 pound per B.H.P. hour, which would result in a theoretical hourly operating cost of:

$$\frac{0.42 \text{ pound per B.H.P. hour} \times 198 \text{ H.P.} \times \$0.05 \text{ per gallon}}{7.4 \text{ pounds per gallon}} = \$5.63$$

With a lubricating oil cost of 50¢ per gallon, the cost of lubricating the engine per hour of operation would be:

$$\frac{250 \text{ H.P. (engine rating)} \times \$.50 \text{ per gallon}}{3000 \text{ rated H.P. hours per gallon}} = \$.042$$

The total fuel and lubricating oil costs would then be approximately \$.563 plus \$.042, or a little over \$.60 per hour.

A few years ago this company prepared a set of curves which show clearly the operating characteristics of a diesel-centrifugal pumping unit at varying capacities and constant head. There were also

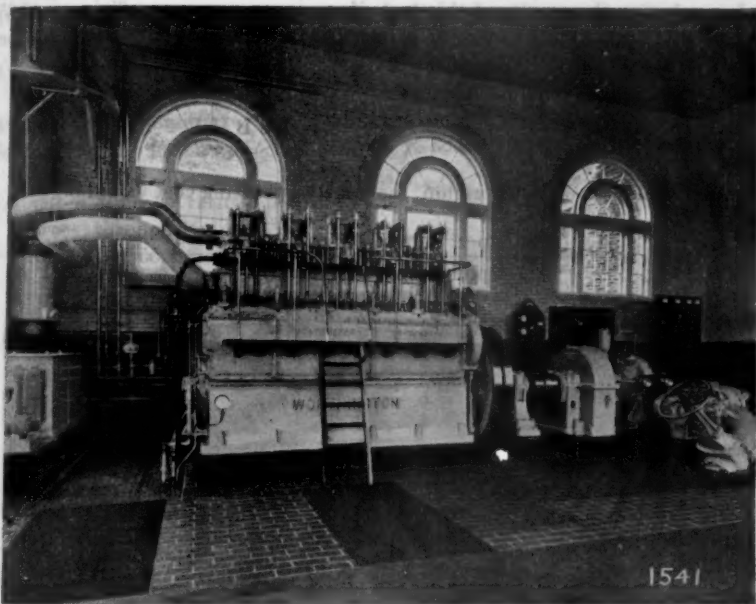


FIG. 1. DIESEL ENGINE AND CENTRIFUGAL PUMP ASSEMBLY—
NASHUA, N. H.

prepared charts which are valuable in making a quick check on "duty" and "fuel cost" of different sizes of diesel-centrifugal plant. They were reproduced in this JOURNAL (Vol. 23 (1931), page 337 et seq.). In the use of these charts, it is assumed that the efficiency of the pump is known.

Many municipalities obtain their water supply from deep wells. The manner in which an engine may be direct connected to a deep well pump is shown in figure 2.

TABLE 1

TEST	DURATION, HOURS	SPEED, R.P.M.		CAPACITY, G.P.M.	HEAD, FEET	FUEL CON- SUMPTION POUNDS PER HOUR
		Engine	Pump			
1	5	366	1304	4402	146.4	81.4
2	1½	366	1304	3470	169.8	75.6
3	1½	387	1377	2920	201.0	78.2
4	1½	377	1345	4595	159.8	92.2

In analyzing the results of this test, if we assume a pump efficiency of 85 percent and a gear efficiency of 97 percent, the brake horsepower load on the engine in Test No. 1 would be:

$$\frac{4402 \text{ g.p.m.} \times 146.4 \text{ feet}}{3960 \times 0.85 \times 0.97} = 198 \text{ B.H.P.}$$

With a fuel oil cost of 5¢ per gallon, the hourly operating cost would be:

$$\frac{81.4 \text{ pounds per hour} \times \$0.05 \text{ per gallon}}{7.4 \text{ pounds per gallon}} = \$5.5$$

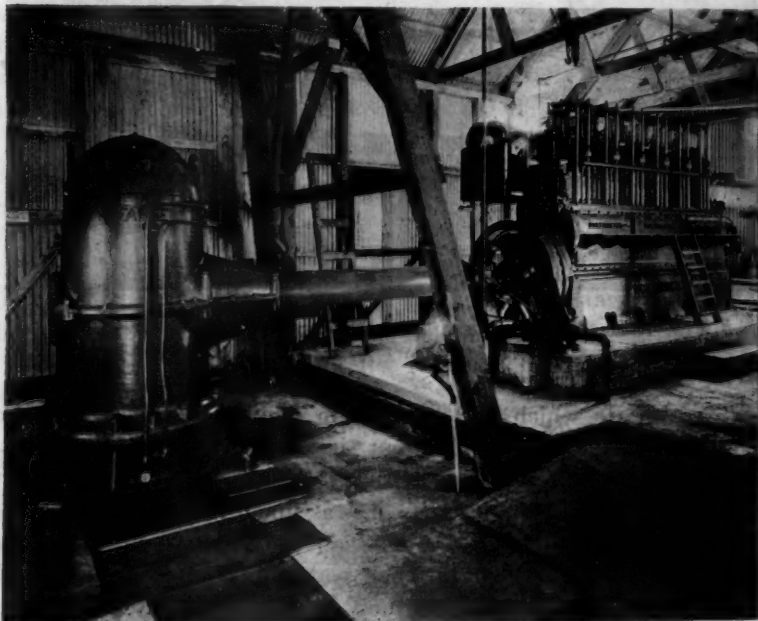
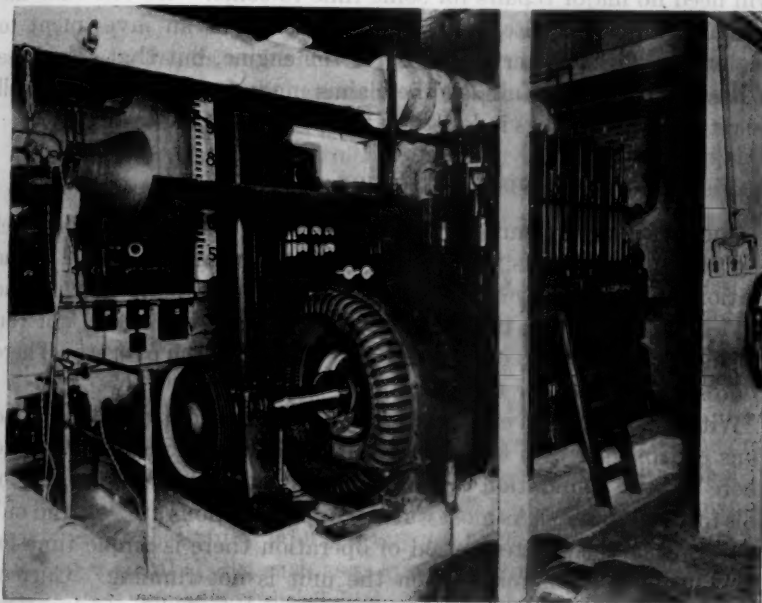


FIG. 2. GAS ENGINE CONNECTED THROUGH GEAR TO DEEP WELL PUMP AT ETIWANDA, CAL.

TABLE 2

	1ST YEAR OPERATION ENDING JULY 1, 1935	2ND YEAR OPERATION ENDING JULY 1, 1936
Total power produced	326,000 K.W. hrs.	390,100 K.W. hrs.
Average fuel consumption, K.W. hours per gallon	10.7	10.4
Total lubricating oil used	289 gal.	398 gal.
Average cost of fuel oil	4.6¢ per gal.	4.87¢ per gal.
Average cost per K.W. hour ..	5.28 mills	5.93 mills
Total cost of maintenance and repairs	\$325.00	\$204.00
Average hours per day plant operation	15.4	15.4
Average engine loading	43.0%	50.5%
Savings—over purchased power	\$3,468.00	\$3,543.00
Estimated time to retire en- gine cost through savings	4.45 yrs.	4.6 yrs.

FIG. 3. DIESEL ENGINE DIRECT CONNECTED TO GENERATOR AT
MIDLAND, MICH.

In 1934, the Water Department of the City of Midland, Michigan, installed a 200 H.P. Diesel engine direct connected to a 137 K.W. generator. This plant provides power for water pumping and utilizes the waste heat from the jacket water and exhaust for heating the building and slaking the lime used for water treatment. An unusual feature of this plant is the application of the exhaust gas to the recarbonation process. A year's experience showed that this gas is a very satisfactory substitute for oil and coke and has several advantages over these more common sources.

The original calculations on which the engine was purchased were based on retiring the investment in ten years. It was estimated that an additional saving of \$1,000.00 per year might be possible under this plan. Just how conservative these figures were, is shown in the second annual report which the superintendent, Paul Stegeman, has prepared. Table 2 gives excerpts from this report.

The last paragraph of this report states: "In conclusion, we feel that the engine is operating satisfactorily, and that it is reliable and will need no major repairs for some time to come. We feel that the purchase of an oil filter might be considered as an investment to prolong the life and serviceability of the engine, but that otherwise it has in all respects fulfilled the claims made for it and that it will be retired from savings in less than five years."

HOW MUCH ATTENTION IS REQUIRED?

One of the more common questions asked in connection with diesel engine pumping plants regards the need of constant attention at the station. Among those who have had little or no experience with the modern diesel engine, there seems to be a belief that it will not run satisfactorily unless an operator keeps constant watch over it. There is no sound reason for this opinion.

With many modern engine plants establishing continuous full-load runs of from three to six months without a shut-down of any kind there is little foundation for an argument against the reliability of this form of power. As most water pumping stations are "off and on" load, during the greater period of operation there is ample time for check-up and adjustment when the unit is not running. Current diesel engine designs, incorporating heavy duty type construction, ample bearing areas, full force feed lubrication to all running gear, fuel pumps, injection nozzles and valve mechanism built of high grade steel alloy to watch-like precision, and modern factory production

methods with tool room accuracy, have practically eliminated all field troubles and have made this form of power fully reliable.

Several plants have been installed incorporating automatic control. Some of these are completely automatic in operation. They will start from cold when the tank level drops to a predetermined point, and will continue to operate until the pressure has been restored. While these installations are practical from a design standpoint, they must of necessity be somewhat complicated and, therefore, more vulnerable than the semi-automatic or manually controlled plant.

There seems to be very little demand for the full automatic diesel pumping station at present. Most installations are well adapted to manual starting. There are sound reasons, however, for a plant which will automatically shut down when the water tank is full or when for any reason the engine cooling water supply or lubricating oil pressure is inadequate. Simple devices are available for this service which add very little to complicate the plant and are entirely reliable in operation.

IS FUEL SUPPLY ADEQUATE?

Many engineers and water works superintendents have expressed concern over the continuation of an adequate supply of diesel fuel oil at reasonable prices.

In 1925 the American Petroleum Institute published a report showing that the proved oil reserves of the United States were about 7 billion barrels. In the following 10 year period to January 1, 1935, nearly $8\frac{1}{2}$ billion barrels of oil had been taken from the ground, and yet at that time the leading geologists agreed that there were still proved reserves of over 12 billion barrels. While these figures are encouraging we know, of course, that there is a definite limit to our natural petroleum supply. There seems little likelihood, however, that this will be depleted during the active life of most of us.

Scientists and engineers are, however, actively engaged on the problem of developing substitutes for this natural liquid fuel. Oil shales and coal provide an almost inexhaustible supply of fuels which are now being successfully liquefied but not as yet on a competitive cost basis. Vegetable oils, such as peanut, cocoanut, soy bean and palm, have been refined for diesel fuel. All of these sources will be developed, and if and when we ever have to forego the use of natural petroleum as a fuel for diesels, we will not only have unlimited supplies of other fuels but it is entirely probable that these new types

will be available at prices lower than those which we are now paying.

It is interesting to follow the price trend of diesel fuel during the last 12 years. Table 3 taken from the Oil and Gas Journal shows the yearly fluctuation.

These prices are at the refinery. Transportation costs to destination and intermediate profits are, of course, included in the individual plant cost. However, as these added costs are fairly constant, the yearly variation is clearly indicated in this tabulation.

TABLE 3

YEAR	PRICE—CENTS PER GALLON—OKLAHOMA REFINED OIL 32-36 A.P.I.		
	High	Average	Low
1923		2.66	
1924		2.91	
1925	3.75	3.68	2.75
1926	4.50	4.19	3.50
1927	4.50	2.99	2.37
1928	2.63	2.47	2.38
1929	3.00	2.65	2.25
1930	2.88	2.27	1.66
1931	2.00	1.27	.54
1932	3.13	2.18	1.23
1933	3.00	2.32	1.64
1934	3.13	2.68	2.23
1935	3.13	2.83	2.53

The 1935 A. S. M. E. Oil Engine Power Cost Report contains the fuel cost data on the 167 plants reporting during that year. Of this number 109, or 65 percent, paid less than 5¢ per gallon of fuel delivered in the plant storage tanks. This oil showed a median gravity of 32 A.P.I.

OPERATING DETAILS

In addition to its economy and reliability the modern diesel engine is simple in design and operation. Anyone who knows the construction of an automobile engine will find the diesel much simpler by comparison. Steam engineers who have worried along with the operating and maintenance troubles of stokers, boilers, feed pumps, heaters, condensers and engines or turbines find the running of a diesel an easy task.

The auxiliary elements of the complete diesel engine plant are few and familiar to all of us.

The cooling water system usually consists of a direct or straight pass through the engine jackets to waste. If water is expensive or not suitable for jacket cooling because of hardness, a closed system may be used. Small centrifugal pumps and heat exchangers of the shell and tube type are the most complicated items of this circuit.

Starting air for cranking the engine is furnished by a small compressor, either electric motor or gasoline engine driven. This air is stored in tanks and is automatically released into the diesel cylinders when starting.

Fuel oil is stored in tanks of the proper size for the most economical purchasing and is transferred to the engine room day tank by a rotary pump. It flows from the day tank to the engine by gravity.

Air for combustion may either be taken from the engine room or from outdoors. A filter should always be used in the intake. If extreme quietness of operation is desired an intake silencer can also be used.

The exhaust should be a simple and direct run to atmosphere through a suitable silencer. The degree of quietness required will govern the refinement of this apparatus.

Lubricating oil treatment may consist of a simple continuous filter mounted on the engine or a centrifuge which is operated independently of the engine. While a centrifuge is the more costly it will soon pay for itself in the prevention of engine wear and the saving of oil.

In general, the modern diesel engine is a recognized and accepted prime mover which has been time-tested in almost every type of power application. It is particularly well suited to the definite requirements of the water pumping plant and will, we believe, find an increasing place in this field.

(Presented before the New Jersey Section, October 24, 1936.)

DIESEL ENGINES AT THE FREEHOLD, N. J. WATER WORKS

By W. J. SCHIVEREA

(Borough Engineer, Freehold, N. J.)

In 1923 it became necessary to modernize the water supply system of the Borough of Freehold, N. J. because of increase in demand and the high cost of operation of inefficient machinery. The water plant was established in 1890, and expanded from a small plant of three flowing artesian wells, and a steam pump, until in 1923 the equipment consisted of three 50 H.P. boilers, two air compressors for air lift system, and of two duplex steam pumps, of 750,000 and 1,000,000 gallons capacity respectively, pumping to a stand pipe of 235,000 gallons capacity. The water was taken from ten 8-inch wells 100 feet deep.

Due to the simplicity and proven reliability, it was decided to continue the air lift system. The efficiency, however, was increased by deepening the wells from 100 feet to 200 feet, which gave a submergence of approximately 70 percent instead of 40 to 45 percent. In the modernization of plant additional mains were constructed, additional storage provided, and system metered 100 percent. The serious problem then was to decide on the power plant. The increasing cost of operation was an acute issue. In 1922 the cost of fuel alone, that is, coal, freight and cartage amounted to \$18,040.01, for pumping an average of 17,000,000 gallons per month. The metering of the system cut consumption from 17,000,000 to 9,000,000 gallons per month.

After considering carefully several proposals and visiting several plants where equipment was in operation, and factories where equipment was manufactured, it was decided to use oil or diesel engines for power, and this has proven to be a very wise decision. Electric power was seriously considered, but in 1923 rates for power were considerably higher than they are today. The power station was 15 miles away with transmission lines constructed across open country so there was danger, and there is today, of interrupted service.

The plant equipment at Freehold consists of two units. Each unit consists of an Ingersoll Rand 100 H.P.—P.O. Type Horizontal Oil engine, directly connected by a coupling to a 12-inch x 10-inch air compressor, and a 4-inch—600 g.p.m. Cameron centrifugal pump short belted to engine fly wheel and accessories. Each unit cost \$12,000 completely installed. The capital expenditure for two units was \$24,000.

The engines are of the single acting, single cylinder, 4 cycle type, 17-inch bore by 19-inch stroke. Direct or solid injection of fuel is used. The engines operate at a speed of 247 r.p.m. The engines are started with compressed air. It requires from 160 to 200 pounds pressure of air to start them. This is produced by a small gasoline engine driven air compressor and receiving tank furnished as accessory equipment.

The water is raised by air lift system from wells whence it flows to a receiving basin. It is pumped by centrifugal pump against a head of 200 feet to a stand pipe and elevated tank. Thence it flows by gravity to distribution system. During the thirteen years of service, the maintenance costs have been very low. In regular service, the engines are run alternately for a period of two months at from 10 to 12 hours per day. The only major repairs were in 1931 when new liners were placed in cylinders. The reason for this was that the engines began to use considerable oil. They were found to be worn about 0.015 of an inch.

In 1931, the local power company with a lower rate for power and improved service endeavored to interest the Borough officials in the use of electric power for pumping, which they claimed would be cheaper than diesel power. A motor driven compressor and pump were purchased and installed at a cost of approximately \$3,000.00. It was agreed by the power company that if after a test and fair comparison of costs electric power did not prove cheaper there would be no charge for service unless equipment was run longer than 15 minutes, which was ample time for equipment tests. The officials thought this would be a good opportunity to obtain an electric power unit as a standby.

It was decided to base test on the cost of pumping 1000 gallons of water based on the cost of a month's operation. The results were as follows:

One month's—Diesel Engine cost

Life of equipment assumed to be twenty years.

Maintenance and repair @ \$3.00 per H.P. per year.

Cost of Diesel unit..... \$12,000

Running time..... 399 hours per month

Water pumped..... 14,569,000 gallons per month

Water pumped per hour..... 36,514 gallons

Fuel oil used..... 2,006 gallons

Fuel oil cost @ .06..... \$120.36

Cooling water..... 700 gallons per hour (total 279,000 gallons per month)

Cooling water at fuel and oil cost..... $279 \times .878 \text{ cent} = \2.45

Interest, insurance, taxes, Sinking Fund.. 11.72 percent or \$117.20 per month

Labor per month..... \$320.00 (2 men at \$160.00 per man)

Diesel lubricating oil..... 10 gallons @ .60 = \$6.00

Compressor lubricating oil..... 3 gallons @ .60 = \$1.80

Maintenance and repair..... \$13.63 per month.

Total cost pumping 1000 gallons water:

$$\frac{\$120.36 + \$2.45 + \$117.20 + \$320 + \$6.00 + \$1.80 + \$13.63}{14.569} = \$0.0397$$

Sinking Fund items on idle equipment = \$146.50 per month, or \$1.01 per thousand gals. 3.97 cents + 1 cent = 4.97 cents total cost.

Electric costs

Cost of electric equipment..... \$3,000.00

Running time..... 440 hours 50 minutes

Water pumped..... 14,290,000 gallons

Gallons per hour pumped..... 32,416 gallons

Electric consumption..... 38,710 K.W. hours

Cost of electric power:

Demand charge 84 H.P. @ 1.50 = \$126.00

3000 K.W. hours @ .03 = 90.00

3000 K.W. hours @ .02 = 60.00

14,000 K.W. hours @ .015 = 210.00

18,710 K.W. hours @ .0125 = 233.88

38,710 K.W. hours \$719.88

Cost per K.W. hour..... \$0.0186

Current cost per 1000 gallons..... $\frac{\$719.88}{14,290} = \0.05037

Cooling water..... 200 gallons per hour (total 88,000 gallons)

Cost of pumping cooling water..... $88 \times 5.037 \text{ cents} = \4.43

Interest, insurance, tax, Sinking Fund.... 11.72 percent or \$29.30 per month

Labor..... \$320.00 per month.

3 gallons compressor oil..... \$1.80

Total cost pumping 1000 gallons:

$$\frac{\$719.88 + \$4.43 + \$29.30 + \$1.80 + \$320}{14,290} = \$0.753$$

Maintenance and repair not included

Sinking Fund items on idle equipment = 1.64 cents per 1000 gallons pumped

Total cost $7.53 + 1.64 = 9.17$ cents.

CONCLUSION

The operation of the equipment at the water pumping plant of the Borough of Freehold, N. J., for the past thirteen years, has well established the reliability and economy of the Diesel Engine as a prime mover.

(Presented before New Jersey Section, October 24, 1936.)

NEW PUBLICATIONS

Electrical Conductivity of Fire Streams¹

Water Department officials, in their contact with Fire Department operatives, have become aware of the dangers associated with high voltage electric lines in fire areas. There is the simple danger from contact with broken lines which still carry a charge. But it has been also understood that the stream of water itself used in fire-fighting could act as a conductor of some current from the exposed electric wire through the nozzle, and the hands and body of the fireman to the ground.

At the request of the Fire Chiefs of Indiana, Purdue University made a study of the electrical conductivity of fire streams.

"The studies included the following investigations: (a) Measurement of the amount of electricity carried down a fire stream from a high-voltage line bearing voltages varying from 440 volts to 100,000 volts, to nozzles of standard sizes (1-inch, 1½-inch, and 1¾-inch) under varying pressures and distances.

(b) Studies to determine the variation in the conductivity of water samples used by fire departments of different Indiana cities.

(c) Determination of a recommended safe distance at which a fireman can safely hold a nozzle directing water on a line energized at a known voltage."

"The tests were conducted upon the campus of Purdue University in the rear of the Electrical Engineering Building, at which point the desired line voltage could readily be secured from the High-Voltage Laboratory. Water for the tests was obtained from a fire plug connection to the University water mains. A South Bend pumper owned by the West Lafayette Fire Department equipped with a Hayes Rotary pump was located at the hydrant with 250 feet of 2½-inch hose between the pumper and the nozzle. The nozzle used was a Colt nozzle with interchangeable openings of 1-inch, 1½-inch, and 1¾-inch diameter. The nozzle was fastened to an adjustable, insulating, wooden support. The line conductor consisted of a No.

¹ Electrical Conductivity of Fire Streams, by C. S. Sprague and C. F. Harding. Purdue University Engineering Bulletin No. 53. (1936). \$0.25.

4 bare copper wire stretched tightly about four feet above the ground and at right angles to the fire stream. The conductor was insulated for the maximum of 100,000 volts used in the tests. The distance from the nozzle to the conductor was varied by moving the nozzle support."

"The method of obtaining the readings was as follows. With the conductor de-energized, the nozzle support was moved to provide the desired distance from nozzle to conductor. The fire stream was then turned on and the nozzle pressure was determined by means of a Pitot gauge. The desired nozzle pressure was obtained by adjusting the pressure at the pumper until the Pitot gauge at the nozzle gave the proper reading. The nozzle pressure was then maintained at this value by keeping the pumper pressure constant as determined by instruments on the pumper. With the fire stream adjusted for the desired pressure and distance to the conductor, the angle of elevation of the nozzle was then adjusted so that the conductor was in the middle of the fire stream.

"The conductor was then energized; the voltage on the conductor was gradually raised to the desired value; and the current reading was obtained and recorded. The voltage was then raised to the next value, another current reading obtained, and so on.

"For short distances from conductor to nozzle, the current readings were quite steady; but as the distance was increased, the ammeter would fluctuate more and more until at the greatest distances of about 36 feet the meter pointer would read zero the greater portion of the time, with only an occasional indication of current flow. These fluctuations were, of course, due to the changes in the continuity of the stream when it began to break up at some distance from the nozzle. In all cases where fluctuation was observed the meters were watched for a considerable length of time and the maximum observed indication was taken as the current reading."

The results of the studies are shown in a series of graphs in the report. The tests were made with a water having a resistivity of 1900 ohms per milliliter at 63°F.

Data obtained on Indiana waters disclosed a range in resistivity from 710 ohms/ml in a deep well water to 5400 ohms/ml in a filtered Ohio River water. It is of course understood that resistivity increases with decrease in mineralization or hardness and decreases as the mineralization or hardness increases.

"The tests and results described have had to do with the compara-

tively definite problem of determining the magnitude of the current which may flow to ground via the fire stream under various conditions of voltage, length of stream, etc. To formulate, from the results of these tests, arbitrary rules or specifications for safe distances from lines of given voltage is a problem not nearly so definite. One may, of course, assume a certain value of current as the safe maximum value. From this assumption, if the conductivity of the water and the voltage of the line are known, one may determine from the preceding curves the minimum safe distance from the nozzle to the line conductor. Such a procedure is relatively simple, but the results depend entirely upon the value of current chosen as the safe maximum value.

"It has been estimated that at a frequency of 60 cycles per second, which is usually supplied by electric light and power companies, a current of 1 milliamperere will just be felt; currents of 4 to 10 milliamperes, depending upon the individual, will cause a sense of pain; a current of 30 milliamperes may cause unconsciousness; and a current of 100 milliamperes is dangerous and may be fatal. The statements involving currents up to 30 milliamperes are based upon tests using human subjects, with the duration of the current at least sufficiently long for the subject to analyze and register the sensation.

"While naturally no tests have been made upon human beings at the higher currents, the analysis of cases of accidental shock and the results of tests upon animals have led to the rather general agreement that at the higher currents the duration of current flow is perhaps the most important factor in determining the extent of the injury.

"In the case of a fireman grasping a hose nozzle, the maximum safe current is limited, not by consideration of personal injury as a result of the current flow itself, but rather by the condition that the fireman must not lose control of the nozzle, which, if released, would become a source of extreme danger.

"From the preceding data, it would seem safe to establish an upper limit of 3 milliamperes for the current which may flow down the fire stream. This current flowing through the body of one person would admittedly produce a slight feeling usually described as a tingling sensation, but would not cause severe discomfort or distress. Actually, the selection of this value of current is still further on the safe side for the reason that usually at least two firemen are detailed to handle the nozzle, so that the current would divide between the two.

"It is well known that the nervous reaction of different individuals to small currents varies very widely. Some persons appear to be hypersensitive, so that the faintest tingle, or possibly even the knowledge that an electric current is passing through their bodies, causes them to become panic-stricken. While it is quite possible that in a few cases the physiological makeup of a person may be such as to cause strong reactions to very small currents, it would, in a large number of cases, seem probable that the reaction is largely of a mental nature, being induced by fear of a mysterious, unknown, and therefore terrifying experience. Whatever the reasons, it would

TABLE 1

Safe distances from high potential lines

Nozzle pressure, 50 pounds per square inch

Nozzle size, 1½ inches

Minimum safe distances for given resistivity in feet

VOLTS	RESISTIVITIES							
	500	1000	1500	2000	3000	4000	5000	6000
440	11	7	5.5	4.5	3	3	3	3
1,100	30	18	14	12	8.5	6.5	5.5	5
2,200	*	30	23	20	15	12	9	8
4,400	*	35	31	28	23	19	16	15
6,600	*	*	34	33	30	26	23	22
13,200	*	*	*	*	33	31	29	28
22,000	*	*	*	*	*	*	*	*

* At these resistivities, for the respective voltages, and for all voltage above 13,200 volts, the fire stream should not be allowed to strike the line.

unnecessarily hamper the operations of firemen to prescribe clearances and distances based upon the reaction of hypersensitive persons, especially when it seems quite possible that such persons could be assigned to duty at points not involving the hazard of electric shock.

"Assuming, then, that the large majority of persons can stand at least 3 milliamperes without severe discomfort and without excessive physical reaction, one may determine the safe distances from lines of various potentials by reference to the experimental data contained in the report. In table 1 such distances are presented for lines of various voltages and for water of various degrees of conductivity.

The application of these may, of course, involve some modification as indicated by the particular conditions."

"The safe distance values as given in table 1 have included a generous factor of safety for the following reasons:

1. In the experimental work the currents measured were the maximum possible currents.
2. A current of 3 milliamperes should not injure any normal person.
3. With the nozzle handled by two men, the probability is that the current will divide between the two men.

"It will be seen that, in the choice of minimum safe distances, the worst possible conditions were taken. Hence it is felt that the results may be considered as amply safe for all conditions."

Their conclusions and recommendations are:

- "1. Fire streams should not be allowed to strike high-tension lines of phase voltages above 13,200 volts.
- "2. The safe distances as given in table 1 will limit the current flowing down the fire stream to a maximum value of 3 milliamperes.
- "3. It is suggested that all fire hose be manufactured with a flexible metallic conductor laid under the outer protective covering and bonded to the couplings at each end of the section of hose. This would provide a direct metallic ground for the nozzle and would provide a low impedance path to ground for any current which might be conducted down the fire stream.
- "4. It is suggested that firemen become familiar with the sensation produced by a current, say, of 3 milliamperes at 60 cycles. Familiarity with this sensation and the direct knowledge that no injury will result might very well minimize the fear of electricity. Also, such a procedure would indicate to those in charge any particular individuals whose reaction to such small currents might be excessive."

This report is a valuable document for the field of its interest. A bibliography citing a number of references to physiological effects of electric current is appended to the document.

H. E. JORDAN.

ABSTRACTS OF WATER WORKS LITERATURE

Key: JOURNAL of the American Water Works Association, 29: 1, 10, January, 1937. The figure 29 refers to the volume, 1 to the number of the issue, and 10 to the page of the JOURNAL.

FILTRATION

Filter Sand for Water Purification Plants. Proc. A.S.C.E., 62: 1543-80, 1936. Committee's Progress report on studies begun in 1926 dealing with sand as a filtering medium and not including less extensively used materials such as coal. **Part I. General Report.** Co-operative filtration tests were carried out by 16 cities with various types of water supplies. Tests were made in batteries of small glass-tube filters. Uniform filter media and methods of testing used by all cooperating plants. Present trend in engineering practice indicates range in effective size of filter sand between limits 0.40 mm. and 0.55 mm. Indications of tendency to adopt coarser sands where conditions permit, a practice which is, in general, justified by the experimental work reported. Coarse sands tend to (1) produce longer runs, (2) produce better "efficiency of wash," (3) permit greater penetration of floc. **Part 2. Detailed Results of Experimental Studies.** Series of experiments reported on were undertaken because too many factors enter into problem of proper filter sand size to allow reaching conclusions along theoretical lines. Experiments were made on highly alkaline waters of Middle West, water from Great Lakes, and softer and more highly colored waters of Atlantic Seaboard. Suitability of any particular filter sand was judged by (1) its efficiency in removing suspended matter; (2) its ability to pass a large volume of clear water between washes; and (3) the ease with which sand can be cleaned with wash water. In these studies term clear water applied to a filter effluent when turbidity was less than 0.2 p.p.m. A filter run was considered complete when loss of head reached 8 ft. and effluent was clear, or when turbidity exceeded 0.2 p.p.m. Condition first reached terminated the run. Properly treated water was term used for a treated water containing no colloidal turbidity; critical depth was term applied to that point in the sand bed beyond which the turbidity of water washed from the portion considered was less than 10 p.p.m., when volume of wash water used was in proportion of 1-1 to each $\frac{1}{2}$ in. of sand; term top size refers to the rated size of sand in the top layer of a filter bed. Experimental filters consisted of pyrex glass tubes approximately $1\frac{1}{2}$ in. diameter and 5 to 6 ft. in length equipped with mercury manometer for determining loss of head, and filter rate controller; apparatus so located to have same level of applied water as on regular plant filter units. Plant settled water used. In discussion term effective size of sand was not used because in these experiments sand was arbitrarily graded and in filter divided into various layers, and size of the upper layer or top size used as a means of comparison. Top sizes from 0.37 to 1.75 mm. were com-

pared, and layer of the top size was of sufficient depth to remove most of the suspended matter coming on to the filter, except in the coarser grained filters. Surprising development was the length of runs obtained with filters having sand of a top size 1.17 and 1.75 mm. respectively, these runs being exceptionally long before reaching 8 ft. loss of head or passing floc. Micro-organisms shortened filter runs considerably. Observation of filter washing in glass units gave considerable information regarding this operation. In filters containing fine sand floc penetration was observed to be very slight and a thin layer of compact sediment formed on top of the sand surface which was readily broken by wash water. Instead of being carried out with floc however, portions of it settled back into the sand bed. Floc adhering to the fine sand grains reduced the specific gravity and then could not be washed off without washing at a rate sufficient to carry over sand. Report gives 3 reasons why fine sand is not properly cleaned during washing: fineness of the sand makes it possible for the floc to envelop the sand grain entirely; irregularity of the grains makes it difficult to remove the floc; at ordinary rates of washing sand expansion is so great to prevent striking together of grains to loosen floc. The action in coarse grained filters differs in that runs are materially longer, accumulation of loose floc is produced on the surface and no tough cake is formed. On washing, accumulation is easy to break through and remove. Particles do not settle into the sand bed, and very little floc remains adhering to sand grains after settling into place. From observations made, it appears that, to keep filters clean certain minimum velocity of wash water is necessary. If this velocity is high enough to agitate filters properly, cleansing effect will be greatest with that sand that has the lowest expansion. Method for determining efficiency of washing is given. Limited number of experiments with filters having uniform size sand grains also described. Summarized with no thought of finality, in general it was found: (a) a good effluent can be secured with any size of sand provided layer is of proper depth; (b) depth of filter sand should be increased as grain size increases; (c) runs increase in length as size of sand increases; (d) efficiency of filter wash is primarily dependent upon rate at which water is applied, but also is affected by the viscosity of the water and duration of the wash; (e) wash water rate should be increased as temperature of water increases; (f) experiments seem to indicate filters with top sizes from 0.60 mm. to 1.00 mm. will give satisfactory results; sizes of 0.50 mm. and less give short runs, require frequent washing, and are difficult to keep clean; (g) a limited number of tests apparently show that an ideal filter should be composed of sand of uniform size. Tests and conclusions are based on turbidity removal and not on removal of bacteria due to various plant difficulties in carrying on additional bacterial tests and because in regular plant operation a sparkling clear filter effluent is usually of good bacterial quality. Report includes numerous graphs summarising individual plant results as well as giving composite curves that aid greatly in explaining data given. Appendix also attached giving information as to objects of the experiments, character of water used and description of apparatus employed.—*Martin E. Flentje.*

SOFTENING AND IRON REMOVAL

The Control of Lime-Soda Water Softening Plants by Means of a Nomogram.
F. W. STAFFELDT. Gas- u. Wasserfach, 78: 623, 1935. From Chem. Abst.,

29: 7536, November 10, 1935. Total hardness, phenolphthalein alkalinity, and methyl orange alkalinity of treated water having been determined, reference to chart will indicate whether chemical dosage has been correct.—*R. E. Thompson.*

Recent Progress in the Application of Zeolites. Desalting of Sea Water. Sterilization of Water. G. AUSTERWEIL and B. KOURAKINE. 14me Congr. chim. ind., Paris, October 1934, 7 pp. From Chem. Abst. 29: 5959, September 10, 1935. Zeolitic aggregates composed of copper zeolite and sodium or calcium zeolite were used. Sea water is desalted by passing through sodium-copper zeolitic aggregate, which it leaves as solution containing only copper salts, chiefly cupric chloride. Solution is treated with copper powder or sponge copper, which precipitates cupric chloride quantitatively as cuprous chloride. After separation of precipitate, trace of cuprous chloride which remains in solution is removed by passing through small sodium zeolite filter. Cuprous chloride is suspended in small quantity of water and electrolyzed, giving sponge copper and cupric chloride, which are reused in cycle. Whole process therefore consists of closed cycle into which there is added only small quantity of electrical energy. Drinking water is sterilized by passing through calcium-copper zeolite and copper-sodium zeolite in series. In passing through the first, water becomes charged with copper salts in sufficient quantity to kill all bacteria present, and in second it is freed from copper. Water leaves the apparatus sterilized and softened. Zeolitic aggregate is regenerated by means of theoretical quantity of sodium chloride. The copper never leaves apparatus, traveling back and forth between the two zeolitic masses.—*R. E. Thompson.*

Aids for Working with Hard Water. FRITZ OHL. Spinner u. Weber, 53: 33, 8-11, 1935. From Chem. Absts., 30: 198, January 10, 1936. For industrial purposes, water is softened either in special installations or by use of washing softeners. Latter being less expensive, is more suitable for textile industry. Softeners include:—(1) soda; (2) alkali bases; (3) mixtures containing soda and water glass, or other silicic acid compounds; (a) same plus soap; (b) same plus borax, trisodium phosphate, etc., with and without soap; and (4) sodium phosphates, or alkali salts of silicic or phosphoric acids. Use of each is discussed and composition given of various commercial water softening powders of German manufacture. Various phases of water softening discussed.—*R. E. Thompson.*

Some Problems of Deferrization and Demanganization. R. S. WESTON. J. New Eng. W. W. Assoc. 50: 231-38, 1936. Iron can most easily be removed from hard waters moderately high in mineral matter and free from much organic matter. Simple aeration, short storage and filtration treat this type of water satisfactorily. Most difficult to treat are soft waters with little mineral matter, considerable organic matter, and in which ratio of manganese to iron is such that one interferes with the removal of the other. When iron and manganese are present as sulfates difficulty also arises. In usual treatment oxygen must be introduced and CO_2 or other acid displaced. To promote com-

plete oxidation it is necessary in some waters to provide contact aeration. Pyrolusite, a manganese ore, has recently been used as a contact medium by Zappfe and others. Manganese is more difficult to remove than iron though it belongs to the same chemical family. In some cases contact upward flow aerators are most effective but must follow adequate preliminary aeration. Organic matter hinders removal probably because its presence prevents agglomeration of iron and manganese particles. Increase of pH to 8.4 will eliminate practically all iron and manganese. Filter alum aids in coagulating precipitated material. Manganese zeolite, sodium zeolite treated with manganese chloride, has been successfully used for manganese removal, the cost of the potassium permanganate required for regeneration being from \$1.50 to \$2.50 per m.g. Considerable data concerning 15 iron and manganese removal plants given in table.—*Martin E. Flentje.*

Removal of Acid and Carbon Dioxide from Water. A. EMUNDS. Schlager u. Eisen, 32: 93-5, 1934; Chem. Zentr., 1934, II, 1176; cf. C. A., 28: 4508. From Chem. Abst., 29: 6678, October 10, 1935. Topics discussed are calcium-oxide-carbon-dioxide equilibrium, various processes for neutralization of acidity, and removal of carbon dioxide with calcium oxide. Importance of good mixing and careful adjustment of calcium oxide dosage are emphasized.—*R. E. Thompson.*

Purification of Bog Water with Lime. N. D. R. SCHAAFSMA. Mededeel. Dienst Volksgezondheid Nederland. Indie, 24: 2, 56-68, 1935. From Chem. Abst., 29: 6985, October 20, 1935. When small amounts of lime were added to bog water, soluble calcium salts of humic acids were formed which were not decomposed by carbon dioxide. Filtered and neutralized water was very hard and high in organic matter. Lime dosage in excess of 1 gram per liter precipitated calcium salts of humic acid and increased alkalinity. After filtration, calcium-saturated water was neutralized, final hardness being from 5° to 7°.—*R. E. Thompson.*

Stabilization of Ferruginous Waters. A. GUILLERD. Tech. sanit. munic., 30: 58-60, 1935. From Chem. Abst., 29: 7535, November 10, 1935. Citric acid is recommended for treatment of waters which are troublesome through constant formation of iron deposits. At Ville de Paris de Franconville, France, addition of 22 p.p.m. sodium citrate to water containing 3 p.p.m. iron stabilized iron and improved quality of water at small cost.—*R. E. Thompson.*

STERILIZATION

Sterilization by Chlorine and Its Compounds Appears as a Simple Oxidation Effect. ÉD. IMBEAUX. Tech. sanit. munic., 30: 157-9, 1935; cf. C. A., 28: 1431. From Chem. Abst., 29: 7538, November 10, 1935. Sterilizing power of chlorine solutions varies with oxidation potential.—*R. E. Thompson.*

Chlorinating Method Improved at Los Angeles. RAY L. DERBY. Civil Eng., 5: 558-61, 1935. From Chem. Abst., 29: 8189, November 20, 1935. Layout of chlorinating stations has been standardized and control made auto-

matic. Solution lines are of hard-rubber piping. Chlorination is employed only at times of surface runoff in rainy season. Addition of ammonia assists in maintaining residual chlorine.—*R. E. Thompson.*

The Use of Ammonia for the Chlorine-Fixing Power of Water. IV. The Influence of Some Physical Factors (Light and Temperature) on the Chlorination of Preammoniated Water. M. L. KOSHKIN and E. M. SPECTOR. *Z. Hyg. Infektionskrankh.*, 116: 688-96, 1935; cf. *C. A.*, 28: 5557. From *Chem. Abst.*, 29: 5959, September 10, 1935. Chlorine-fixing power of water increases with intensity of light to which it is exposed, both before and after ammoniation, value being lower in latter case. Also, chlorine-fixing power increases with increase in temperature, value being lower for preammoniated water. Bactericidal action of chlorine increases with increasing temperature, with or without preammoniation. Fluctuations of chlorine fixing-power under influence of light and heat are less when water has been preammoniated.—*R. E. Thompson.*

The Significance of Ammonia for the Chlorine-Fixing Power of Water. V. pH of the Water and Preammoniation. M. L. KOSHKIN. *Z. Hyg. Infektionskrankh.*, 117: 182-9, 1935; cf. *C. A.*, 29: 5959. From *Chem. Abst.*, 29: 8189, November 20, 1935. Increasing pH from 2.8 to 8.2 reduces chlorine-binding capacity by from one-third to one-half. In preammoniated water reduction is greater. Preammoniation prevents chlorophenol tastes and odors if pH is 7.0 or higher. Bactericidal action of chlorine in water, preammoniated or not, decreases as pH increases.—*R. E. Thompson.*

Water Purification at Perth, Scotland: Chloramine Treatment. CYRIL WAMESLEY. Surveyor, 87: 517-18, 1935. From *Chem. Abst.*, 29: 7535, November 10, 1935. In addition to keeping reservoirs clear of vegetable growths, chloramine has been found greatly superior to chlorine as sterilizing agent. Owing to lower oxidation rate, it is not affected to same extent by variations in chlorine demand; dosage, therefore, does not need as frequent adjustment. There is also less risk of taste trouble. Bacteriologically, results are all that could be desired, and cost is very small.—*R. E. Thompson.*

TASTE AND ODOR REMOVAL

Improvement of Taste, and Biological Investigation of Surface Water. WALDEMAR PRANG. *Gas- u. Wasserfach*, 78: 421-9, 1935. From *Chem. Abst.*, 29: 7765, October 10, 1935. While activated carbon filters improved taste of Pregl (Königsberg) water, they soon became clogged with aluminum hydroxide and attempts to remedy this condition were unsuccessful. Potassium permanganate, powdered carbon, slow sand filtration, etc., were only partly successful. Treatment finally adopted was precipitation with ferric chloride with simultaneous addition of potassium permanganate. Organic substances were largely precipitated and taste of water improved. Powdered activated carbon and prechlorination were also used. At another works, fishy taste was found to be due to *Synura uvella*. Addition of 1 gram copper sulfate per cubic meter destroyed *Synura*, but other plankton organisms

were apparently unharmed. Various treatments to remove taste and odor are discussed and graphs given for chemical and biological analysis of several reservoirs over period of 3 years.—*R. E. Thompson.*

Dechlorinating Power of Non-Activated Charcoals in Comparison with Commercial Activated Ones. L. A. KULSKIĭ and P. B. MORITZ. *Ukrain. Khim. Zhur.* 9: 185-91, 1934. From *Chem. Abst.*, 29: 6339, September 20, 1935. Water can be filtered and dechlorinated simultaneously by passage through birch or pine charcoal (I). **Application of Activated and Regenerated Charcoals to the Dechlorination of Water.** L. A. KULSKIĭ and L. M. GLAZMAN. *Ibid.*, 193-219. Highly active product (II) is obtained by treating I, saturated with chlorine, with hot 1- to 2-normal sodium hydroxide; activity of II increases with each repetition of process. This effect is not obtained with commercial activated charcoals.—*R. E. Thompson.*

BOILER FEED WATER

Critical Considerations upon the Return of Boiler Sludge with a Stream of Water to the Purifier. HANS RICHTER. *Allgem. österr. Chem. -und Tech. -Ztg.*, 52: 80-3, 1934. From *Chem. Abst.*, 29: 8190, November 20, 1935. Removal of sludge, consisting of magnesium carbonate and permanent hardness, from boiler water by method proposed in title is impossible, both because flow of water is too small and because of danger of stoppages. Boiler sludge is best removed at very short intervals (of 1 to 2 hours) at same time that water-treating salts are drawn off. The temperature and salt content are thus equalized. Suction can be so applied as to increase efficiency of sludge removal.—*R. E. Thompson.*

The Varying Behavior of Zinc Plates in the Boilers of the German Railway. R. KÜHNEL. *Ber. Korros. -Tag.*, 1933: 42-6, 1934; *Chem. Zentr.*, 1934: II, 2129. From *Chem. Abst.*, 29: 6678, October 10, 1935. Zinc plates hanging in boiler should protect it against corrosion. Behaviour of plates varied extraordinarily with age. Seven plates, containing 0.01 to 0.02 percent iron and 0.95 to 1.7 percent lead, were tested in practical operation. The harder the plate, the more satisfactorily it functioned. Value of plates as measured by their age agreed with that measured by their strength and hardness.—*R. E. Thompson.*

Chemical Deaeration of Boiler Feed Water. I. The Facts. SHEPPARD T. POWELL. *Power*, 79: 304-6, 1935. From *Chem. Abst.*, 29: 6678, October 10, 1935. Theories of corrosion reviewed. Repeated saturation with carbon dioxide or nitrogen and evacuating, use of metals or metallic oxides, activated charcoal, sulfur compounds, etc., have been proposed. Ferrous hydroxide has been used. Tannins and pyrogallol are effective. One gram pyrogallol absorbed 0.37 gram oxygen from solution of 20 per cent potassium hydroxide.—*R. E. Thompson.*

Chemical De-aeration of Boiler Feed Water. II. Practical Applications. SHEPPARD T. POWELL. *Power*, 79: 362-3, 1935; cf. *C. A.*, 29: 6678. From

Chem. Abst., 29: 7536, November 10, 1935. Use of sodium sulfite for de-aëration is described.—*R. E. Thompson.*

Routine Analysis of Boiler Feedwater Sources. S. H. COLEMAN. Power Plant Eng., 39: 577, 1935. From Chem. Abst., 30: 198, January 10, 1936. Routine analyses should be made not only of water in boiler, but also of that in various parts of system and of raw water sources. Such analyses may show variations in raw water, or leaks in circulation system.—*R. E. Thompson.*

Alkalinity of Internally Treated Boiler Water. C. N. RIDLEY. Steam Engr., 4: 429, 463-4, 1935. From Chem. Abst., 29: 7536, November 10, 1935. Discussion of alkalinity of boiler water, as affected by reactions between soda reagents introduced and hardness of different types; also of behavior of certain calcium and magnesium salts in boiler water, by taking advantages of which, saving may be effected in chemicals, with corresponding reduction in accumulation of soluble salt.—*R. E. Thompson.*

Efficiency of Oil-Field Boilers Can Be Increased by Treating Feed Water. I. F. BINGHAM. Oil and Gas J., 34: 16, 51-2, 1935. From Chem. Abst., 29: 7536, November 10, 1935. Boiler compounds and chemical reactions involved are classified and lime-soda-alum method described.—*R. E. Thompson.*

Attack of Hydrogen Sulfide on Boiler Walls. N. CHRISTMANN. Wärme, 58: 534, 1935. From Chem. Abst., 29: 7537, November 10, 1935. Numerous investigations of failed sections of boiler showed new type of attack which indicated possible connection with adherent scale from boiler water. Proof was obtained that potassium and sodium sulfates are reduced to sulfide by hydrogen formed from steam at high temperature and pressure. Steels with especially good resistance to hydrogen sulfide attack, such as chromium-aluminum base material, are advocated for temperatures up to 650°. Nickel addition up to 9 percent for temperatures up to this limit is not harmful. At higher temperatures, nickel would be detrimental, since easily molten nickel-sulfur eutectic would be formed. Aluminum has good effect in resisting sulfur gases and, with increasing temperatures, higher aluminum contents are necessary. Silicon-chromium-aluminum steels are also suggested for this service.—*R. E. Thompson.*

Caustic Brittleness. V. V. IPATIEFF, JR., and N. M. OSTROUMOV. Trans. VI Mendeleev Congr., 1932, 2, 1, 266-73, 1935. From Chem. Abst., 29: 7899, November 20, 1935. Samples of iron and steel were investigated in high-pressure bomb filled with sodium hydroxide solution heated during 1 to 2-month period in air thermostat. Solutions containing 300 grams per liter at 300° do not lead to changes in boiler iron similar to those attributed to caustic brittleness if not subjected to load overstrains. This is true for media deprived of oxygen, or saturated with either hydrogen or oxygen.—*R. E. Thompson.*

Treatment of Feed Water for High-Pressure Boilers. J. LENOCH. *Wochbl. Papierfabr.*, 66: 455-8, 1935. From *Chem. Abst.*, 29: 7536, November 10, 1935. Feed water satisfactory for steam under 12 atmospheres may be entirely unsuited to boilers operating at 35, or more, atmospheres: softeners for high pressure work must be selected with care. Ideal, which is never reached, comprises:—(a) freedom from gases (especially oxygen); (b) residual hardness approaching zero; and (c) freedom from corrosive chemicals, or substances causing injury due to decomposition at high temperatures. Various pretreatments are suggested, which, in general, are followed by final treatment with trisodium phosphate: latter serves to precipitate calcium and magnesium and prevents silicate scale formation when suitable precautions are taken to remove sludge.—*R. E. Thompson.*

Caustic Embrittlement of Steel Accelerated by Silicates. W. C. SCHROEDER and A. A. BERK. *Eng. News-Rec.*, 116: 379, March 12, 1936. Brief data given from cooperative study with Joint Research Committee on Boiler Feed Water Studies reported before American Institute of Mining and Metallurgical Engineers (Technical Publication 691). Previous experience and investigation had established that caustic soda, in boiler water or elsewhere, in contact with steel at elevated temperature brings about serious embrittlement. In present study, it was found that sodium hydroxide alone produces either no embrittlement, or only slow weakening of moderate amount. Commercial sodium hydroxide, such as used in earlier investigations, was found to contain substantial amounts of other salts (sodium carbonate, sodium chloride, sodium silicate, and various metallic oxides). None of these, in combination with sodium hydroxide, was found to have noticeable embrittling influence, except sodium silicate. Further experiments showed that additions of from 0.15 to 3.0 percent sodium silicate will render chemically pure sodium hydroxide capable of producing embrittlement. Microscopic examination revealed, as one of chief characteristics of action of silicate-hydroxide solutions, great number of almost completely intercrystalline cracks in steel. Stress concentration intensified weakening effect.—*R. E. Thompson.*

The Corrosion of Boilers and of High-Pressure Apparatus. V. V. IPATIEFF, Jr. *Trans. VI Mendeleev Congr.*, 1932, 2, 1, 260-4, 1935. From *Chem. Abst.*, 29: 7920, November 20, 1935. Most corrosion processes can be classified as either:—(1) corrosion of boilers by water and admixtures present in it; (2) alkaline corrosion at high temperatures and in cases of high concentrations of alkalis; (3) hydrogen corrosion at high temperatures and pressures; or (4) corrosion by gases containing sulfur and phosphorus and by liquids. In first case, improvement may be obtained by addition of alkalis, which lowers amount of free energy between iron and water, but at same time allowance must be made for formation of oxide layer, which appears to passivate surface of iron when formed by influence of oxygen; wherefore, oxygen is admissible in high-pressure boilers at beginning of process. Hydrogen corrosion is much more dangerous for steel and for many other metals on account of its very high activity. Carbon steels offer little resistance to it. Their mechanical strength remains unchanged under 250°, but decreases rapidly at higher tem-

peratures. After action of hydrogen, material becomes of large-grained crystalline structure, grows in dimensions, and degenerates. Soft iron does not deteriorate in mechanical properties.—*R. E. Thompson.*

CORROSION

Corrosion of Copper. M. PARMENTIER. *Métaux (Aciers spéciaux)*, 9: 418-20, 1934. From Chem. Abst., 29: 7921, November 20, 1935. General review of mechanism of corrosion of copper. Seventeen references.—*R. E. Thompson.*

The Possibility of Preventing Corrosion in Hot-Water Systems. L. W. HAASE. *Gesundh.-Ing.*, 58: 621-4, 1935; cf. C. A., 29: 4496, 7263. From Chem. Abst., 30: 417, January 20, 1936. Factors responsible for corrosion in various types of hot-water systems and means of combating such corrosion are reviewed.—*R. E. Thompson.*

Corrosion of Wrought Iron Pipes by Water. WILHELM RADEKER. *Gas- u. Wasserfach*, 78: 793-4, 1935. From Chem. Abst., 30: 418, January 20, 1936. Conditions under which ferrous metal pipes are used are as important as composition of metal. Analyses of corrosion products are valuable in determining causes of corrosion. In one case, deposits from pipe which had failed in short time showed high carbonate content, because of high carbon dioxide content of water. In absence of oxygen, deposits consist of equal parts of ferrous and ferric oxides; latter predominates in presence of dissolved oxygen. Case of local corrosion due to oxygen is discussed.—*R. E. Thompson.*

Some Aspects of the Corrosion Problem in a City (Gas) Plant. CHARLES F. TURNER. *Natural Gas*, 16: 7, 10-12, 1935. From Chem. Abst., 29: 6872, October 20, 1935. Replacements of piping are more frequent in city or town distribution systems than in transmission lines through open country. Author believes that because of frequent replacements in congested areas, use of pipe coatings to retard corrosion will more than offset cost of coating by postponing replacements. Corrosion due to stray currents is discussed and opinion expressed that after but few years underground, resistance of coating is reduced to zero and that coating will in many cases invite trouble, rather than prevent it. Trend is toward decreased use of coatings where possibility of stray current electrolysis exists because at small areas where break in coating occurs electrolytic action is intensified.—*R. E. Thompson.*

Symposium on Corrosion Resistant Metals. F. N. SPELLER, E. H. DIX, R. B. MEARS, G. O. HIERS, E. A. ANDERSON, H. L. MAXWELL, R. A. WILKINS, J. H. CRITCHETT, F. L. LARUE. *Mech. Engr.*, 58: 781-843, 1936. Includes introductory paper and one on each of the following subjects: Aluminum and Its Alloys; Corrosion Resistant Lead Equipment; Zinc in the Chemical Industries; Cast Iron in Chemical Equipment; Copper and Copper Base Alloys; Corrosion Resistant Stainless Steels and Irons; Nickel and Nickel Base Alloys. The introductory paper discusses the nature and occurrence of corrosion, caused, first, by factors associated with the metal and, second, by factors

associated with the environment. Metal and environment must be mated so as to live together peaceably, at least until the owner has had a reasonable return on his investment. The problem of the engineer is to select the metal that will serve best any specific purpose at the lowest ultimate cost. Each paper on a specific metal presents extensive data and discussion on the composition, uses, physical properties, trade names and commercial availability of all forms of the metal and its alloys. Exhaustive bibliographies accompany several papers.—*Homer Rupard.*

Corrosiveness of Certain Ohio Soils. I. A. DENISON and S. P. EWING. *Am. Soil Survey Assoc. Rept. 15th Ann. Meeting, Bull. 16:* 81-4, 1935; cf. *C. A.*, **28:** 6687. From *Chem. Abst.*, **29:** 6195, September 20, 1935. Corrosion of old pipe lines appears to be definitely related to certain Ohio soil types. Repairs to pipe lines have been made in areas of Chinango silt loam, Holly clay loam, and Mahoning silt loam; but rarely in areas of Wooster loam, Canfield silt loam, Ellsworth silt loam, or Volusia loam. Index of corrosion damage for each soil type is given by relation $P = 7500 (A-5)/R$, where P is percentage pipe repaired, A , average soil acidity (*C. A.*, **27:** 2748), and R , average resistivity of soil. Moist, or poorly drained, soils are more corrosive, because of anodic action, than drier soils. Mature soils are less corrosive than immature types. Corrosiveness increases with heavier texture in subsoil.—*R. E. Thompson.*

A Mathematical Theory of Corrosion. J. F. BRENNAN. *Gas Age-Record*, **75:** 359-64, 1935. From *Chem. Abst.*, **29:** 7920, November 20, 1935. For equivalent moisture conditions, depth of pitting on bare steel pipes may be expressed as $y = [A + Bz] \log [(x/h) + 1]$, where y is depth of pitting, x is age of pipe in years, and z is soil corrosivity index. Constants A , B , and h can be evaluated by mathematical methods from observations and laboratory test data.—*R. E. Thompson.*

Preparation of Iron and Steel for Painting. V. M. DARSEY. *Ind. Eng. Chem.*, **27:** 1142-4, 1935. From *Chem. Abst.*, **29:** 7921, November 20, 1935. Methods of preparation are described under headings of alkali and solvent cleaning, surface roughening by sand- and shot-blasting and acid pickling, and non-metallic phosphate coating. Latter appears to give greatest protection to steel.—*R. E. Thompson.*

Paints for Water-Tank Interiors. H. N. BASSETT. *Railway Engr.*, **55:** 405-6, 1935; *Met. Abstracts*, (in *Metals & Alloys*) **6:** 289. From *Chem. Abst.*, **29:** 8363, November 20, 1935. Galvanized iron is not suitable for water reservoirs. Waters vary greatly in corrosive properties, particularly rain water in industrial districts and surface water in moorland, or chalk and limestone areas. Tests were carried out by Egyptian State Railways on 64 non-metallic coatings. Results indicated only one as satisfactory, namely, a lead chromate priming coat mixed with specially flexible vehicle (to avoid cracking on temperature changes) followed by coating of aluminum varnish. Tests were exhaustive and samples were immersed in baths of condensate for 30 days, partly

at elevated temperatures. Red lead alone is not entirely satisfactory for water containing chlorides; chromate is required in addition. Weathering of steel tanks is very important for removing mill scale; process is accelerated by brushing down with solution of sal ammoniac, which, however, requires careful washing and drying. American experience showed best results with chromate priming coat and 2 finishing coats of synthetic gum varnish. Four other satisfactory paints consisted of aluminum powder in elastic water-proof synthetic resin vehicle, thinned down to working consistency with mineral spirits. Red lead in 3 coats ranked third with respect to kind of water stored.—*R. E. Thompson.*

WATER SUPPLY—GENERAL

Water Supply Problems in the Tropics of Spanish America. G. C. BUNKER. *J. New Eng. W. W. Assoc.*, 50: 1-98, 1936. Comprehensive paper discusses in detail water supply problems affecting countries in torrid zone, particularly those in Central and South America. Contrary to general impression these countries are not all low, uncomfortably hot and humid and having torrential rain storms; but exhibit many variations of climatic conditions depending largely on altitude. Design of water supplies greatly handicapped by lack of maps, records of rainfall and stream flow, and passable roads. Annual mean rainfall varies from 18 to 280 in. Few evaporation studies made. In Canal Zone yearly total between 52 and 65 in. Earthquakes fairly frequent and must be considered in design of plants. Experience has shown properly designed reinforced concrete and structural steel buildings will withstand severe earthquakes with minor, if any, damages. **Surface Water Supplies.** Usual sources of water supply are surface streams, usually swift running with quick spilling watersheds. Deforestation is promoting rapid erosion and streams are flashy with high turbidities. Majority of catchment areas subject to much unnecessary and careless pollution by inhabitants and travellers. Salt springs sometimes present. Suitable natural lakes rarely encountered and no impounding reservoirs exist because of cost and lack of money. **Ground Water Supplies.** Among the larger cities obtaining water largely from ground water sources are Lima and Callao, Peru; San Salvadore, El Salvador; Cartagena, Colombia; San Jose, Costa Rica; and Iquique, Chile. There because of its desert location 75 mi. pipe line was laid to bring in ground water. **Water Supply for Small Communities.** Little progress made in the provision of potable water to numerous small communities in which from 70 to 88 percent of total population live. **Temp. of Water Supplies.** Surface supplies in the coastal cities will fluctuate from 80° to 84°F, from 64° to 72°F at 3000 to 4000 ft. altitude, and from 46° to 55°F at 8000-10,000 ft. **Estimates of Population.** No general rule for estimating future population of tropical cities can be given. **Estimates of Water Consumption.** In cities of 10,000 or more per capita consumption does not exceed 105 g.p.d., runs as high as 88 g.p.d. in some of the larger cities without meters, will average about 60 g.p.d. in cities with climate like Panama City and Colon, and seldom drops below 50 g.p.d. **Fire Service in the Tropics.** In water supply design for tropics provisions should be made for ample fire protection but on smaller scale than in North Amer. cities, except in business districts. **Water-**

Borne Diseases. In addition to the water borne diseases found in North Amer., the diseases caused by protozoa and parasitic worms are more common in tropics than in temperate zone. Part played by water in the transmission of these diseases is far more important than has been recognised in the past. Author believes, in time, purification of all tropical and sub-tropical surface supplies by filtration and disinfection will be considered absolutely essential. Bacteriological exam. of water is not as useful in these regions because these tests do not indicate definitely protozoa and parasitic worms are absent. Among the diseases caused by these organisms are Schistosomiasis, *Schistosoma mansoni*, Ancylostomiasis, Ascariasis, and more important Amebiasis. A considerably higher percentage of the population is infected with amebiasis than the 5 to 10 percent estd. in the U. S. While difference of opinion exists as to extent to which amebiasis is transmitted by water, believed several conclusions can be drawn from experience and experimental work,—(1) cysts in feces deposited on watershed during dry season and exposed to bright tropical sunlight will be killed ordinarily before the feces are conveyed to the nearest surface stream, (2) cysts in feces deposited on watershed subjected to rain on 25 days or more of each month will be conveyed to a surface stream while they are still alive, (3) cysts in feces deposited on watershed at high altitudes, with air temperature of 0° to 5°C during the night—rising to 7° to 12°C during the day, with little or no sunlight, will survive for at least 48 hrs. and reach a stream uninjured if rain falls within this period, but that if no rain falls within 48 hrs. cysts will probably die. Asiatic cholera has rarely occurred in tropics in recent years. **Treatment of Water Supplies.** Chlorination has been recommended in number of cases although filtration and chlorination are most desirable. Rapid sand filtration is preferred over other means of purification and personnel required can be obtained and trained in these countries. Number of suggestions are made regarding design factors of purification plants to meet tropical conditions. **Present Status of Water Purification.** A summary is given of the present status of water supplies in Central and South American countries lying within the tropics. In Panama it is estimated about 23 percent of the population is supplied with water of good sanitary quality and 40 percent of the remainder with well water. In Colombia the author estimates 4 percent use filtered water and 6 percent of remainder use chlorinated water. Very little progress in the treatment of water supplies has been made in Venezuela. In Ecuador 4.5 percent use filtered and chlorinated water and 6 percent chlorinated water. Similar data given for Peru, Bolivia, Nicaragua, Salvador, Honduras, Guatemala, and Costa Rica. **Conveyance and Distribution of Water.** Steel pipe usually used for transmission mains, though open channels often used instead of pipe. Black iron, galvanized-steel and some copper and brass used for services. Practically all supplies municipally owned and few metered. **Impounding Reservoirs in Panama Canal Zone.** Water first taken for Canal Zone came from 4 impounding reservoirs. Relatively little trouble experienced with tastes and odors. Aeration was found very effective. Of microscopic organisms found protozoa were most numerous amounting to 43 percent of all found. Of these Peridinium, Glenodinium and Dactylosphearium occurred in greatest abundance. Chara later became source of trouble and expense. **Influence of Sea Water on Intake for Water Supply.** A descrip-

tion is given of effect of salt water, coming in through one of the locks, on water used for water supply from Miralores Lake, later abandoned.—*Martin E. Flentje.*

New Water Supply System and Filter Plant at Hinsdale, N. H. A. L. SHAW. New Eng. W. W. Assoc., 50: 315-324, 1936. 315-24. With aid of a P. W. A. grant Hinsdale N. H. obtained a new water supply which was placed in operation in fall of 1935. Impounding dam built on Kilburn Brook raising level of existing reservoir, Kilburn Pond, 70 m.g. additional capacity gained. Below this intake dam and reservoir of capacity 0.3 m.g. also built, to which water from upper reservoir flows down the brook. Water often has color over 100 and pH as low as 5.0. A 0.20 m.g.d. treatment plant also built, consists of a welded steel mixing tank 7 ft. in diam. and 11 ft. deep, providing for flash mixing and longer mechanical agitation of usual type. Alum and soda ash are used for coagulation with soda ash for final pH correction to 7.5-8.0. The 2 coag basins are of covered reinforced concrete, round the end type, each 14 x 25 x 8.5 ft. avg. depth. The 2 cylindrical filters are steel, 7 ft. in diam. with perforated C. I. pipe strainer system. Color reduced from 100 to 8. Distribution system consists of approx. 8000 ft. 8 in. C. I. transmission main, 0.25 m.g. covered standpipe, C. I. main of 6 to 12 in. diam., in all approx. 4 mi. of pipe. System designed to supply fire flows of 1000 g.p.m. with residual pressures of 10-20 lb. and 3000 g.p.m. with residual pressure of 50 lbs. in center of village. Total cost of system \$126,000. Operation is under direction of Board of Water and Sewer Commissioners.—*Martin E. Flentje.*

Little Rock to Acquire New Water Supply. Eng. News-Rec., 116: 365, March 5, 1936. New supply system for Little Rock, Arkansas, which has lately acquired its local distribution system, will include impounding dam on Alum Creek and gravity-flow conduit to existing filter plant on Arkansas River. Dam will be of earth, 110 feet high and 2,800 feet long. Conduit, 39 inches in diameter, will be 32 miles long and will have rated capacity of 22 m.g.d. In contrast to present Arkansas River supply with hardness of 200 to 400 p.p.m., Alum Creek water has hardness of only 15 p.p.m. and low turbidity.—*R. E. Thompson.*

WATER SUPPLY—QUALITY

Coshocton Water Found Sanitary. Eng. News-Rec., 116: 362, March 5, 1936. As result of outbreak of gastro-enteritis, February 18-19, water supply of Coshocton, Ohio, derived from wells near junction of Walhonding and Tuscarawas Rivers, was investigated by State Department of Health. Although study indicated that flood water could enter well system, samples collected from distribution system 3 days after epidemic were without exception satisfactory and it was concluded that it was improbable that water supply was responsible for outbreak. Supply is chlorinated.—*R. E. Thompson.*

Pollution Tests for Drinking Water Need Further Investigation. A. M. BUSWELL. Eng. News-Rec., 116: 415, March 19, 1936. Brief data from paper read before Illinois Society of Engineers, in which were discussed changes in

standards of purity for drinking water. Attempts to correlate chemical data with dangerous pollution were abandoned 30 years ago. Notwithstanding great advance in and large amount of research carried out on bacteriological technic, main problem, that of identifying or detecting human fecal pollution, remains unsolved. Safe standard for pure drinking water has been developed, but comparatively little progress has been made in determining what is unsafe water.—R. E. Thompson.

Studies on the Survival of Eberthella Typhosa in Surface Waters and Sewage. H. HEUKELEKIAN and H. B. SCHULHOFF. N. J. Agr. Expt. Sta., Bull. 589, 2-32, 1935. From Chem. Abst., 29: 8191, November 20, 1935. Rate of decrease of *Eb. typhosa* in polluted water and sewage is rapid and is affected materially by temperature. With favorable temperature, in presence of food supply multiplication may occur, which, however, does not necessarily result in increase in survival time, as rate of decrease after multiplication stage is greater than without initial multiplication. In polluted waters, survival of *Eb. typhosa* is shorter than in unpolluted waters, probably because of competition for food from other bacteria and because of protozoan attack. Aëration reduces survival time. Survival time of *Es. coli* is not affected by presence of *Eb. typhosa*. Number of *Eb. typhosa* is rapidly reduced during anaërobic digestion of sewage solids. In activated sludge there is initial increase, then rapid decrease. When artificially infected sewage is chlorinated partially, destruction of *Eb. typhosa* is of same order as destruction of normal sewage flora. When only 25 per cent of chlorine demand is satisfied, there is over 90 percent reduction of *Eb. typhosa* in 10 minutes' contact time.—R. E. Thompson.

The Effect of Wooded Areas on the Hygienic Quality of Drinking Water and the Effect of Water Withdrawal on Forested Areas. AUG. F. MEYER. Gas-u. Wasserfach, 78: 541-6, 556-60, 579-84, 1935. From Chem. Abst., 29: 6985, October 20, 1935. Wooded areas on watersheds and around reservoirs are usually of hygienic advantage. Possible difficulties due to such areas are discussed and precautions suggested. Cases of alleged damage to forests by lowering of ground water level by wells are discussed. Nature of soil and vegetation are contributory factors.—R. E. Thompson.

Organic Colloids and Their Effect on the Distribution of Material in Waters. WALDEMAR OHLE. Naturwissenschaften, 23: 480-4, 1935. From Chem. Abst., 29: 7535, November 10, 1935. Review of recent work (C. A., 28: 4640) on influence of organic material on distribution of plant nutrients in pools and lakes. Results of filtration of acid and alkaline water of Swedish lakes through Cella filters are given, to show that phosphate is completely available when pH exceeds 7: in acid pH range, it is partly colloiddally bound. Organic (humic) material precipitates iron and manganese from water. Effects are generally explained by rule that, at high pH anion exchange prevails, while at low pH cation exchange prevails.—R. E. Thompson.

Bactericidal Action of Carbonic Acid on Water Bacteria. A. GUILLERD and P. LIEFFRIG. Eau, 28: 94, 1935. From Chem. Abst., 29: 7538, November 10,

1935. Water artificially saturated with carbon dioxide showed practically no bactericidal action against *Esch. coli* or *Eb. typhosus*. Practically no reduction in numbers was evident after exposure of 40 minutes.—*R. E. Thompson*.

Travertine-Depositing Waters near Lexington, Virginia. EDWARD STEIDTMANN. *Science*, 82: 333-4, 1935. From *Chem. Abst.*, 30: 195, January 10, 1936. Waters are supersaturated with calcium bicarbonate throughout year, excess ranging from about 68 to 76 p.p.m. calcium carbonate. Adjustment resulting in deposition of calcite is hastened by rise in temperature, aëration, and presence of calcite. Unaccountably low proportion of carbon dioxide present suggests that much of calcium carbonate which appears to be in solution is really in crystalline colloidal state.—*R. E. Thompson*.

The Factors Which Play a Rôle in the Solution of Lead by Water. KARL HÖLL. *Gesundh.-Ing.*, 58: 323-8, 1935; cf. *C. A.*, 29: 2635. From *Chem. Absts.*, 29: 5959, September 10, 1935. Natural waters to which had been added known amounts of various salts were allowed to stand for various lengths of time (3 to 12 hours, or several days) in length of lead pipe at pressure of Hanover city mains and then analyzed for dissolved lead. Chloride, as potassium or sodium salt, has no appreciable effect until Cl^- concentration reaches 1000 p.p.m. This conclusion is contrary to that of other observers using distilled water who found that amount of lead dissolved decreased with increase in Cl^- . Apparently effect of Cl^- is influenced by other ions present. Except in case of hard waters of pH above 7.5, nitrite concentration of 50 p.p.m. increased amount of lead dissolved by natural water, effect being greater the softer and more acid the water. This concentration of nitrite increased amount of lead dissolved 20 per cent in water with pH under 7. Effect of 100 p.p.m. is noticeable even in hard water with pH above 7.5. Nitrate is of no significance until concentration reaches 200 p.p.m. N_2O_5 . Potassium and sodium sulfates increased amount of lead dissolved only when present in concentrations above 200 p.p.m. (lead dissolved increased from 1.8 to 1.9 when SO_4^{--} was increased from 25 to 300 p.p.m.). Calcium sulfate had more marked effect; increasing content of this salt from 25 to 250 p.p.m. SO_4^{--} increased lead dissolved by approximately 10 per cent. Grounding radio antenna to lead pipe did not influence amount of lead dissolved.—*R. E. Thompson*.

Sodium Chloride in Potable Waters. E. MAYNARD. *Eau*, 28: 53-5, 1935. From *Chem. Abst.*, 29: 7534, November 10, 1935. Human body eliminates about 12 grams sodium chloride daily, far more than average drinking water can supply. French Superior Health Council has set upper limit of 40 p.p.m. of chloride, or 66 p.p.m. sodium chloride, for potable waters. In France, 136 cities have water supplies containing from 15 to 988 p.p.m., and 134 villages or cities have supplies containing over 50 p.p.m. of chloride. In only 33 villages is chloride content less than 15 p.p.m. This study shows that chloride in excess of 40 p.p.m. in French drinking waters is not usually indicative of pollution.—*R. E. Thompson*.

Calcium Sulfate in Potable Waters. E. MAYNARD. *Eau*, 28: 70, 1935. From Chem. Abst., 29: 7533, November 10, 1935. Water of Paris basin contains much calcium sulfate, sometimes in excess of 300 p.p.m. This is of distinct disadvantage for most household uses; but long experience indicates that for drinking purposes it has no harmful effects.—*R. E. Thompson.*

What Constitutes a Satisfactory Water Supply? CLARENCE W. KLASSEN. *Milk Plant Monthly*, 24: 8, 32-7, 1935. From Chem. Abst., 29: 7533, November 10, 1935. Desirable physical, chemical, and sanitary characteristics of dairy water supplies is discussed. Water softening methods are described and suggestions given for preventing pollution from above ground. Advice is included concerning methods of locating proper water supply.—*R. E. Thompson.*

The Treatment of Water for the Paper-Making Industry. A. H. WADDINGTON and R. CLARK. *World's Paper Trade Rev.*, 104: 183-8, 226, 228, 339-44, 386, 388, 1935.—From Chem. Abst., 29: 7651, November 10, 1935. Discussion of water purification for paper-mill processes and brief description of more important developments.—*R. E. Thompson.*

The Alkaline Waters of the Chalk Stratum in the London Basin. J. LE PERSONNE. *Ann. soc. géol. Belg.*, 58: B38-63, 1934-5. From Chem. Absts., 29: 7534, November 10, 1935. There are 2 zones; one of hard, and one of soft, strongly alkaline, water. Softness of latter is due to exchange reactions between water and glauconiferous sands, whereby calcium and magnesium have been exchanged for sodium, as in base exchange softening.—*R. E. Thompson.*

The Iodine Question in Westphalia. RUDOLF BALKS. *Landw. Jahrb.*, 81: 939-1002, 1935. From Chem. Abst., 30: 408, January 20, 1936. Determination of iodine in water, etc. outlined. Iodine content of water varied from 0.00012 to 0.0196 p.p.m. Data given on iodine content of soils, vegetables, etc.—*R. E. Thompson.*

Ten Years of Sanitary Improvements in Rhode Island Public Water Supplies. L. POOL and J. J. DILLON. *J. New Eng. W. W. Assoc.* 50: 143-48, 1936. Revised tabulation giving descriptive data of the public water supplies of Rhode Island is given. 94 percent of the population of this state provided with water from public water supplies. Improvements to existing supplies and treatments and new sources of water supply made in the past 10 yrs. reflected in improved bacteriological quality, mean for all supplies now showing but 5 percent of samples to contain coli aerogenes group in 10-ml. portions, over a considerable period of time.—*Martin E. Flentje.*

LABORATORY METHODS—BACTERIOLOGICAL

The Paracolon Group of Bacteria. B. R. SANDIFORD. *J. Path. Bact.*, 41: 77-88, 1935. From Chem. Abst., 29: 6918, October 20, 1935. "Paracolon" bacilli are coliform organisms which either do not ferment lactose, or ferment it atypically. They always produce indole. Fermentation of rhamnose shows different mechanism from that usually found in bacterial sugar fermen-

tation: gas is redissolved; this indicates that soluble gases other than hydrogen or carbon dioxide are formed.—R. E. Thompson.

The Process of Milk Coagulation for Titer Determination of *Escherichia Coli* in Water. I. E. MINKEVICH and I. I. RAGOSIN. Voenno-med. Zhur., 3: 300-3; Chem. Zentr., 1934, I, 2177; cf. C. A., 23: 4288. From Chem. Abst., 29: 6677, October 10, 1935. Milk test of HUSS (Nord. Hygien. Tidskr., 4: 1932) for determination of *Escherichia coli* in water is impracticable owing to gas formation in whole milk being too slight. Improvement of medium by decreasing lactose and increasing nitrogen content is suggested: 100 cc. skimmed milk is added to solution of 5 grams peptone in 900 cc. warm tap water, mixed, skimmed off, and sterilized. This simple, cheap medium, from readily available materials, suffices for first orientation. Samples showing definite coagulation, separation of casein, and clarification are positive. Results are equivalent to those with usual method. Differential diagnosis is made as follows: (1) lactose fermentation at 37°, 24 hours, indicates *Aquaticus communis*; (2) on Simmon's medium (1.5 grams sodium ammonium sulfate, 1 gram potassium dihydrogen phosphate, 0.2 gram magnesium sulfate, 2.53 grams neutral sodium citrate, 20 grams agar-agar (desalted), and 10 cc. 1.5 per cent alcoholic bromothymol blue solution) at 37° for 24 hours, light blue discoloration indicates *Aërobacter aërogenes*, *Aërobacter cloacae*, or cold-blooded colon bacilli; (3) fermentation test at 46° for 24 hours yielding positive results in combination with (1) and (2) indicates presence of warm-blooded colon bacilli. Identification of colon bacilli in Endo-positive colonies is likewise made. Above coagulation method requires 72 hours. Fermentation and control cultures on Endo require 24 hours. Milk coagulation test alone is reliable in all negative and 85-90 percent of positive cases. Rating of water tested follows: 100 cc. and less negative, very pure; 10 cc. negative, pure; 1 cc. negative, poor; 0.1 cc. negative, highly contaminated. Waters of last 2 classes should not be used without sterilization.—R. E. Thompson.

New Method for the Examination of Water for the Presence of *Escherichia Coli*. B. BABUDIERI. Ann. igiene, 44: 1025-35, 1934; Chimie et industrie, 34: 321-2. From Chem. Abst., 29: 7538, November 10, 1935. The 2 following culture media are prepared: (a) peptone 20 grams, sodium chloride 10 grams, lactose 40 grams, distilled water 1 liter; and (b) peptone 15 grams, sodium chloride 7.5 grams, lactose 30 grams, distilled water 1 liter. Solutions are adjusted to pH 7.4, and 10.5 and 7.5 percent, respectively, tincture of litmus added. One, 3, 5, 10, and 20 cc., respectively, of sample are added to Dunham tubes containing 2, 6, 10 cc. of (b) and 10 and 20 cc. of (a), respectively. Tubes are incubated 24 hours at 37°, and those in which no acidity has developed are discarded; those in which acidity has developed, but no gas produced, are incubated additional 24 hours. Transfer is made from tubes showing both acid and gas to agar-lactose containing 1 percent litmus solution and 1 percent sodium taurocyolate and plates are incubated 24 hours at 44°. If colonies which redden medium develop, 1 or 2 are transferred to gelatin tubes of following composition: peptone 10, sodium chloride 5, glucose 5, gelatin 100, distilled water 1 liter, litmus solution 5 percent, pH adjusted to 7.4. Tubes are

incubated 4 days at 20° and organisms which have reddened gelatin without liquefaction and which have produced gas bubbles are examined microscopically to determine their morphological and tinctorial characteristics.—*R. E. Thompson.*

LABORATORY METHODS—CHEMICAL

A Criticism of the Albuminoid-Ammonia Determination. W. WATSON. *Surveyor*, 87: 469-71, 1935. From *Chem. Abst.*, 29: 7540, November 10, 1935. Albuminoid nitrogen values depend on amount of permanganate added, on rate of distillation, and on method of nesslerization.—*R. E. Thompson.*

Determination of Dissolved Oxygen in Deaerated Water by Winkler's Method. G. W. HEWSON and R. L. REES. *J. Soc. Chem. Ind.*, 54: 254T, 1935. From *Chem. Abst.*, 29: 6677, October 10, 1935. Double electrometric titration method described in detail permits observations of variations of iodine concentration equivalent to 0.001 p.p.m. oxygen, sensitivity markedly superior to that obtainable by titration with starch indicator.—*R. E. Thompson.*

Determination of Carbon Dioxide in Sands. A. T. SVESHNIKOV and E. V. SMIRNOVA. *Zavodskaya Lab.*, 4: 585-6, 1935. From *Chem. Abst.*, 29: 7863, November 20, 1935. Flat-bottom flask (100 cc.) is provided with rubber stopper fitted with dropping funnel and 2 tubes bent at straight angle. Tube with one end close to bottom of flask is for conducting oxygen; other is for gas outlet and connection with Würtz apparatus (for carbon determination in steels). Place 5 grams sand in flask, expel air from flask with oxygen current, connect flask with Würtz apparatus, drop into flask 20 cc. 5 percent sulfuric acid, open stopcock connecting flask with graduated buret (in percent carbon) of apparatus and boil contents of flask 5 minutes. Pass current of oxygen until buret is filled. Determine oxygen point and force gas mixture twice through potassium hydroxide solution for absorption of carbon dioxide. Force remaining oxygen back into buret and mark volume corresponding to absorbed carbon dioxide. Make correction for temperature and pressure and convert percentage carbon into carbon dioxide by dividing by 0.273 and 5.—*R. E. Thompson.*

Estimation of Chloramine in Water Supplies. PAUL D. McNAMEE. *Ind. Eng. Chem., Anal. Ed.*, 7: 333-4, 1935. From *Chem. Abst.*, 29: 7535, November 10, 1935. The pH determines type of chloramine present. Chloramine is estimated by determining ammonia formed therefrom on acidification. Test is not as sensitive as o-tolidin test for free chlorine, but good results are obtained when solution contains 0.2 p.p.m. chloramine-chlorine. Relatively large amounts of free ammonia reduce precision of test, minimizing its value in testing sewage. Test is useful in presence of nitrite and for differentiating between chloramine and free chlorine.—*R. E. Thompson.*

Step-Photometric Determination of Free Chlorine in Chlorinated Water. L. GOLDENBERG. *Mikrochemie*, 18: 235-49, 1935. From *Chem. Abst.*, 30: 197, January 10, 1936. Colorimetric method of ELLMS and HAUSER (*C. A.*, 8: 880, 2990) with acid solution of o-tolidin was studied with photometer. Table

was prepared showing chlorine concentrations corresponding to each 0.1 in drum readings, ranging from 0.84 to 0.077 p.p.m., and possible interference was studied.—*R. E. Thompson.*

Step-Photometric Determination of Manganese in Drinking Water and in Service Water. R. BARIL. *Mikrochemie*, 18: 250-5, 1935. From Chem. Abst., 30: 197, January 10, 1936. SCHMIDT's method (C. A., 22: 1202) which depends upon formation of reddish violet compound when quadrivalent manganese is treated with dimethyl-*p*-phenylenediamine is suitable for photometric measurement. Color is not specific for manganese, but it is easy to avoid interference by other oxidizing agents likely to be present in water. Full directions given for carrying out test with 100 cc. water.—*R. E. Thompson.*

The Determination of Iron in Sea Water. THOMAS G. THOMPSON and RAYMOND W. BREMNER. *J. conseil intern. exploration mer*, 10: 33-8, 1935; cf. C. A., 26: 4551. From Chem. Abst., 30: 407, January 20, 1936. To 100 cc. sea water, add 6 cc. concentrated sulfuric acid and evaporate to strong fumes. Cool, add little water, oxidize with excess potassium permanganate at about 100°, and finally boil with bromine. Expel excess bromine, dilute to 85 cc. at room temperature, add 10 cc. potassium thiocyanate, and extract red ferric thiocyanate with 10 cc. isoamyl alcohol. Compare color with that obtained similarly from known amounts of iron.—*R. E. Thompson.*

The Sulfur Content of Illuminating Gas as a Source of Error in Analytical Work. A. IEVINŠ. *Z. anal. Chem.*, 102: 412-8, 1935. From Chem. Abst., 30: 41, January 10, 1936. Analytical data given show that precipitates of calcium oxide, magnesium oxide, magnesium pyrophosphate, ferric oxide, aluminum oxide, etc., often weigh too much after ignition, because of sulfur in gas used for heating.—*R. E. Thompson.*

The Importance of the Froboese Chlorine Number in the Examination of River Waters. VIKTOR MÜHLENBACH. *Gesundh.-Ing.*, 58: 296-302, 1935. From Chem. Abst., 29: 5958, September 10, 1935. Sewage from city of Riga (over 300,000 population) is discharged, after screening, into the Dūna, flow of which is so large compared with sewage flow that pollution produced is not great. Author sought to determine distribution of sewage throughout cross section of river 655 meters below outfall, where river is 420 meters wide. Sampling points were selected at various distances from shore and at various depths. Several methods of estimating degree of pollution were compared. It was found that alkaline solution of potassium hypochlorite as used in determination of FROBOESE chlorine number (cf. C. A., 15: 913) was more vigorously reduced by nitrogen-containing organic matter than potassium permanganate. Degree of pollution indicated by FROBOESE chlorine number agreed well with that indicated by bacteriological and biological examination. Although highest and lowest chlorine numbers corresponded with maximum and minimum degrees of pollution as indicated by permanganate consumption (KÜBEL-TIEMANN method), oxygen content (WINKLER method), oxygen content after 48 hours, percentage oxygen saturation, and chlorine number determined by

NIKOLAI method, yet FROBOESE number was found to be distinctly more sensitive to slight differences in degree of pollution than the other methods. Oxygen content after 48 hours and oxygen demand were found to be more reliable indices of pollution than oxygen content at time of sampling, or percentage oxygen saturation.—*R. E. Thompson.*

Estimation of the Quantity and the Nature of Organic Material in Drinking Water. RAYMOND BUYDENS. *J. Pharm. Belg.*, 17: 343-7, 359-62, 1935. From *Chem. Abst.* 29: 6336, September 20, 1935. Add 100 cc. sample to 20 cc. solution of sodium hypochlorite in Erlenmeyer flask, heat to boiling in 5 to 5.5 minutes and continue boiling 10 minutes, add 2 cc. 10 percent potassium iodide, cool, acidify with 10 cc. 1:2 hydrochloric acid, and titrate with *N*/50 sodium thiosulfate, using α -naphthoflavone (0.1 gram percent in 96 percent alcohol), to blue spot reaction which changes to lilac, then to dirty rose, and finally pure rose color.—*R. E. Thompson.*

Chemico-Microscopic Detection and Estimation of Fluorine in Mineral Waters. ENRICO PODA. *Ann. chim. applicata*, 25: 225-7, 1935. From *Chem. Abst.*, 29: 6676, October 10, 1935. Micro test of BEHRENS (formation of crystals of Na_2SiF_6) has been adopted in determination of fluorine in mineral waters. Estimation is made by counting crystals formed from known volume of water.—*R. E. Thompson.*

The Use of Aluminon in the Determination of Small Quantities of Aluminum. V. M. PESHKOVA. *Trans. Inst. Pure Chem. Reagents (U. S. S. R.)*, No. 14: 42-8, 1935. From *Chem. Abst.*, 30: 406, January 20, 1936. To 15 cc. neutral solution add 5 cc. normal hydrochloric acid, 5 cc. 3-normal ammonium acetate, and 5 cc. 0.1 percent Aluminon reagent. After 5 minutes add 0.5 cc. 5-normal ammonium hydroxide and 0.5 cc. 5-normal ammonium carbonate. As little as 2.5 γ aluminum will give test, but color varies somewhat if alkali or alkaline earth ions are present: iron should be absent, or added to standards.—*R. E. Thompson.*

Rapid Potentiometric Determination of Minute Amounts of Chlorides. S. V. BUEVICH and F. E. VARFOLOMEIEVA. *J. Applied Chem. (U. S. S. R.)*, 8: 366-72 (in English 373), 1935. From *Chem. Abst.*, 29: 7221, November 10, 1935. Titration of small amounts of chlorides in dilute solutions without concentrating was carried out potentiometrically by TREADWELL method with Cl-Ag electrode. Largest errors were:—for concentrations not below 2.5 p.p.m., 1.2 percent; for those not below 0.5 p.p.m., 12.4 percent. MOHR method was found to be less accurate. Acidity up to 20 milligram equivalents, 20 p.p.m. ferrous or ferric iron, humic substances equivalent to color of 300°, 1000 p.p.m. calcium sulfate, or 1500 p.p.m. magnesium sulfate did not affect results of potentiometric titration. Method can be used for direct determination of chlorides in natural waters.—*R. E. Thompson.*

Microchemical Colorimetric Determination of Sodium. A. ELIAS. *Anales asoc. quim. Argentina*, 23: 1-3, 1935. From *Chem. Abst.*, 29: 7218, November

10, 1935. To prepare reagent, dissolve 50 grams sodium-free $\text{UO}_2(\text{OAc})_2$ in 30 cc. glacial acetic acid and make up to 250 cc. with distilled water. Dissolve 165 grams of pure magnesium acetate in 30 cc. of glacial acetic acid and make up to 250 cc. with distilled water. Mix solutions, allow settlement, and filter after few days. Sample should not contain more than 1 or 2 milligrams sodium oxide per cc. Place 1 cc. of sample in small flask, add 5 cc. reagent, leave 24 hours in refrigerator, add equal volume of pure ethyl alcohol, let stand 20 minutes, filter, wash precipitate 3 or 4 times with alcohol by decantation, test last wash with 2 percent sodium salicylate solution, evaporate alcohol, dissolve and make up to 50 cc. with distilled water. Compare colorimetrically by MÜLLER method (C. A., 14: 1945). Potassium does not precipitate if chloride concentration is less than 10 percent, nor lithium, under 11 percent. Only arsenates and phosphates interfere; they should be removed first. No free mineral acid should be present.—R. E. Thompson.

Methods for Determining Traces of Heavy Metals in Mineral Waters. K. HELLER, G. KUHLE, and F. MACHEK. *Mikrochemie*, 18: 193-222, 1935. From Chem. Abst., 30: 197, January 10, 1936. According to MIHOLOČ, C. A., 28: 2957, 3153, 3814, heavy metal content of mineral water serves to identify probable source of spring. Scheme of analysis is outlined for determining as little as 0.01 p.p.m. of copper, bismuth, lead, cadmium, or zinc. Ions were concentrated by shaking with carbon tetrachloride + dithizone (cf. FISCHER and LEOPOLDI, C. A., 28: 2295) and final determinations were made by polarographic method (cf. HEYROVSKY, C. A., 27: 5270) with dropping-mercury electrode.—R. E. Thompson.

The Use of Sodium Pyrophosphate Combined with Metaphosphate in the Determination of Lead in Drinking Water. P. KARSTEN. *Chem. Weekblad*, 32: 391-3, 1935. From Chem. Abst., 30: 197, January 10, 1936. To avoid difficulty from iron precipitation by pyrophosphate, metaphosphate is added to give correct pH for lead determination: per 80 cc. water containing less than 20 milligrams calcium, 10 cc. 10 percent sodium metaphosphate is added, then 1 gram sodium pyrophosphate, 10 cc. ammoniacal ammonium chloride solution, and lastly 2 drops sodium sulfide solution. Copper is eliminated if necessary by adding 4 drops 10 percent potassium cyanide solution. This procedure allows simple colorimetric determination of lead even in very hard water and in presence of up to 20 p.p.m. iron.—R. E. Thompson.

The Determination of Calcium as Oxide. A. LEVINŠ. *Acta Univ. Latvien-sis, Kim. Fakult. Serija 2*, 465-71 (in German 472), 1935. From Chem. Abst., 29: 7857, November 20, 1935. Determination of calcium as oxide by ignition of carbonate or oxalate in Bunsen burner, or blast flame, leads to error, owing to contamination with sulfate from gases of flame. Correct results can be obtained by shielding, or by igniting in electric furnace.—R. E. Thompson.

LABORATORY METHODS—MISCELLANEOUS

A Photometric Method for the Investigation of Sedimentations. ROLF STEENHOFF and STURE FUNKE. *Tek. Tid. Uppl. C, Kemi* 65: 53-5, 1935.

From Chem. Abst., 29: 6337, September 20, 1935. Extent to which flocculation and sedimentation processes, as in water purification, have proceeded at different periods of time can be determined and expressed numerically by photometric measurements of relative absorption of light in reaction medium. Amount of light which reaches photoelectric cell is expressed in percentage of amount which, under same conditions, passes through pure water. Light absorption is directly proportional to concentration of absorbents and is illustrated graphically from measurements with suspensions of graphite and infusorial earth. Measurements of sedimentation of aluminum sulfate-carbonate in waters after addition of different amounts of aluminum sulfate and small amount of carbon shows that 40 p.p.m. aluminum sulfate is limit for practical purification, being in agreement with experimental results of NORLIN (C. A., 27: 2744). Experimental series, in which amount of aluminum sulfate was held constant at 40 p.p.m. and pH varied, showed that most rapid flocculation and sedimentation occurs at pH 6.2, while at pH 6.8 or 5.1 sedimentation is incomplete. Addition of carbon in amounts above 1 p.p.m., decidedly increases speed of sedimentation, 10 p.p.m. being appropriate amount. Agitation for 15 to 30 minutes causes rapid sedimentation, flocculation being completed during agitation. Final absorption was also found to be greater in media subjected to agitation. Arrangement used is described and illustrated.—R. E. Thompson.

Residue from a Drop of Water Observed Under the Polarizing Microscope. MARIA CASANOVA. Bol. informaciones petroleras, 11: 121, 49-75, 1934; cf. *ibid.*, 1932, No. 99. From Chem. Abst., 29: 6412, September 20, 1935. Type and composition of water from petroleum deposits can be determined approximately by examining under polarizing microscope residue left by evaporation of 1 drop of liquid (preferably adjusted to density 1.01-1.03). Numerous photomicrographs are given and crystallographic data are tabulated for 48 naturally occurring salts which can be formed by evaporation of various types of waters.—R. E. Thompson.

CONCRETE

Subgrader and Concrete Finisher of New Design for Large Canal. Eng. News-Rec., 116: 279-82, February 20, 1936. Colorado River aqueduct being built by Metropolitan Water District of Southern California includes 62 miles of open canal section which will have water depth of 10.2 feet and top width of 57 feet. Out of experience on this tremendous undertaking have come 2 pieces of heavy construction equipment that represent distinctly new types: the subgrader and the monolithic paver or concrete finisher. These machines and their use on canal are described in some detail.—R. E. Thompson.

Design of Reinforcement in Circular Concrete Siphons. D. B. GUMENSKY. Eng. News-Rec., 116: 380-2, March 12, 1936. Reinforced concrete siphons are important feature of Colorado River aqueduct. General principles of design in regard to type and size of siphons and influence of terrain and other conditions were described in Eng. News-Rec., June 27, 1935, p. 899. Present article deals with specific feature of steel reinforcement in circular siphons, of which

there is an aqueduct aggregate length of 24.36 miles, with diameters varying from 11 feet 5 inches to 16 feet. For details original must be consulted.—*R. E. Thompson.*

Removing Fines from Sand with Air Blowers. JOHN STEARNS. *Eng. News-Rec.*, 116: 344-6, 1936. Air segregation of fines from concrete aggregate as developed along the Colorado River aqueduct, where water is neither plentiful nor cheap, is described. Essentially, method consists in passing air upward through pit-run material falling within a vertical pipe in which are fixed buffers or splitters. The fines, consisting largely of dry silicious dust, are carried into a pipe in which is incorporated a trap to catch material coarser than 100-mesh. Moisture content of the pit-run material should be less than 1 percent.—*R. E. Thompson (Courtesy Chem. Abst.).*

DAMS

Shaking Dam Tied Down with Steel Cables. *Eng. News-Rec.*, 116: 286-7, February 20, 1936. Novel method of increasing strength of laterally weak masonry dam section was recently devised by A. COYNE in repairing 2 dams in Algeria. In one case, crest section of dam had been torn off by flood and was to be replaced; in the other, operation was precautionary measure to prevent possible failure of dam of insufficient cross-section. In both, method was to drill holes in masonry from crest to deep foundation, into which steel cables were inserted and sealed into foundation and then stressed with jacks, tension being maintained by tightening anchor head bearing on crest of dam. Details of operation at Cheurfas Dam, which is 107 feet high, are given. Data were obtained from articles by DROUHIN in *Annales des Ponts et Chaussées*, August, 1935, and by G. BARCELO in *Revista de Obras Publicas*, August 1, 1935.—*R. E. Thompson.*

Improved Soil-Plasticity Needle. C. A. HOGENTGLER, Jr. *Eng. News-Rec.*, 116: 463-4, March 26, 1936. Discussion of article by F. B. CAMPBELL (Modified Soil Control Proposed for Rolled-Fill Dam Construction, *Eng. News-Rec.*, January 30, 1936), with particular reference to difference between density as obtained in laboratory tests and as found in actual embankments. Improved plasticity needle designed for laboratory use at George Washington University is described.—*R. E. Thompson.*

Fort Peck Diversion Tunnels Redesigned for Faster Driving. *Eng. News-Rec.*, 116: 450-1, March 26, 1936. Brief details given of revised design of 4 diversion tunnels, varying in length from 5,366 to 7,240 feet, at Fort Peck Dam. Progress at dam last season made it desirable to effect closure in 1937, whereas original design of tunnels would not permit closure until 1938 at earliest. Interior diameter has therefore been reduced from 26 feet to 24 feet 8 inches and 36-inch monolithic concrete lining has been substituted for two-layer concrete and steel-plate diaphragm originally specified. Owing to disagreement on price, contractor gave up contract and tunnels are being completed by government day labor.—*R. E. Thompson.*

HYDRAULICS

Venturi and Weir Measurement. W. S. PARDOE. *Mech. Engr.*, 58: 60-62, 1936. The relative accuracy of venturi tube, rectangular and V-notch weir is discussed. An error of one percent in measuring the head will give a possible error of one-half of one percent in the discharge of a venturi tube, one and one-half percent for a rectangular weir, and two and one-half percent for a V-notch weir. Diagrams of calibration tests for coefficients confirm these conclusions. The change of coefficient for a weir over a period of twenty-two years is discussed and the conclusion drawn that a weir should be considered as a bit of laboratory apparatus, calibrated in place immediately prior to use. The change of coefficient in a venturi tube over a period of fifteen years is shown, and factors which cause changed coefficients are discussed.—*Homer Rupard.*

MAINS AND SEWERS

Frost Penetration as Affected by Weather and Snow Conditions. HARRY U. FULLER. *J. New Eng. W. W. Assoc.* 50, 299-301 1936. Abnormal winter conditions of 1903, 1917-18 and 1933-34 resulted in many frozen water pipes. Author brings up the question if anything can be done to aid water works supt. during such times. Describes studies of cold weather started in 1917-18 and continued in 1924. In the vicinity of Portland Me. ground freezes to 4 ft. depth in Dec. and Jan. without freezing water pipes. Additional cold weather in Feb. when ground water is frozen leads to rapid freezing of water pipes. The reason no freezing occurs in the first two months is resistance offered by the ground to passage of cold, which is changed when ground water becomes frozen. Pipes in Portland are laid in 5 ft. trenches with frost going down nearly to the pipes. In Ottawa Canada Dobbin reports frost down 7½ ft. in severe winters with 6 ft. the usual depth. An expt. to determine actual temps. at various ground depths is described but no results are given.—*Martin E. Flentje.*

Antimonial Lead for Water Pipes. O. BAUER and G. SCHIKORR. *Metallwirtschaft*, 14: 463-70, 1935. From *Chem. Abst.*, 29: 7259, November 10, 1935. Physical and corrosion tests were made on 8 grades of lead containing from 0.003 to 1.40 percent antimony. Addition of antimony increased tensile strength and hardness of lead, increase with 0.9 percent being 40 percent. Wall thickness of water pipes can be correspondingly reduced. Distilled water free from carbon dioxide actively attacked lead. Addition of 0.35 percent antimony reduced corrosion by 60 percent; maximum reduction was obtained with 0.8 percent. With increasing carbon dioxide content, protective coating was formed on pure lead, reducing corrosion almost to that obtaining with 0.8 percent antimony. Local drinking water attacked lead much less than carbon-dioxide-free distilled water, and difference between pure and antimonial lead was slight: minimum attack occurred with 0.8 percent antimony. Water containing humus attacked antimonial lead more than pure lead; but attack was not much greater than with drinking water. Antimonial lead was attacked less than pure lead by 3 percent sodium chloride, artificial North Sea

water, and calcium hydroxide solutions; but more than pure lead by potassium nitrate solutions and moist lime mortar. It is not advisable to lay lead pipes in lime mortar, especially if mortar is apt to become moist.—*R. E. Thompson.*

GROUND WATER AND WELLS

Determining the Yield and Quality of Water from Tubular Wells by Means of the Well Rater and Sampler. P. F. HOWARD. *J. New Eng. W. W. Assoc.*, 50: 219-21, 1936. Article describes apparatus for detng. the quantity and quality of water from individual wells connected to others of a well system. Device consists of a 1½ in. centrifugal pump hooked up to the well casing and discharging through an orifice plate to which a mercury manometer is attached. A similar manometer is connected to the well pipe. In use deflection of mercury in second manometer is detd. before and while well is hooked into the well system, this reading giving water level and drawdown when in service. Then with well shut off from the system centrifugal pump started and sufficient water pumped to give the same drawdown, deflection in first manometer read and the quantity of water being pumped determined. Water samples then obtained simulate operating conditions. Method found useful to predict drawdown of new wells and to eliminate wells having low yields.—*Martin E. Flentje.*

Geologic Features in New England Ground Water Supply. KIRK BRYAN. *J. New Eng. W. W. Assoc.* 50: 222-28, 1936. Small ground water supplies for single homes may be obtained in New England by drilling into hard crystalline bed rock of this area. Larger supplies must be obtained from stratified drifts or sand and gravel deposits left by the retreat of glaciers brief account of a theory of New England glacial history given and attempt made to correlate this with the ground water supply of the area.—*Martin E. Flentje.*

Ground Water. I. Fundamental Principles Governing Its Physical Control. WILLARD GARDNER, T. R. COLLIER and DORIS FARR. *Utah Agr. Expt. Sta., Tech. Bull.* 252, 40 pp., 1934. From *Chem. Abst.*, 29: 1888, November 20, 1935. Mathematical background concerning movement of ground waters is presented in detail. NEWTON's 2nd law of motion, together with elementary hypotheses concerning frictional forces resisting flow of water through soils, leads to DARCY's experimental velocity law generalized for flow in 3 directions. Applications are made to solution of practical problems on flow into wells, watershed erosion, leakage from canals, etc. Modified approximation form of DARCY's law is presented for solution of problems in capillary flow.—*R. E. Thompson.*

Harmful Influence of Ash Heaps on Ground Water. H. HAUPT. *Gas-u. Wasserfach*, 78: 526-8, 1935. From *Chem. Abst.*, 29: 6675, October 10, 1935. Coal ashes, especially from brown coal, may cause contamination of ground water with carbonates, bicarbonates, and sulfates through leaching. Example of such contamination is given, together with warning that continued use of wells may cause course of ground-water flow to change, so that contamination may occur from unsuspected sources.—*R. E. Thompson.*

Plugging Old Artesian Wells to Stop Underground Water Loss. THOMAS M. McCLURE. Eng. News-Rec., 116: 425-7, 1936. Methods employed in New Mexico for plugging abandoned artesian wells are described. Wells are first filled with heavy fluid mud, of specific gravity sufficiently high to overcome artesian pressure; mud is then displaced with cement. To date, 114 wells have been plugged, at average cost of \$250 each, and it is estimated that leakage from artesian basin has been reduced 78 second-feet, or 56,472 acre-feet per season. In addition, about 60 defective wells have been plugged and replaced by 32 new wells. When program has been completed, increase in artesian head throughout basin is expected to average at least 30 feet. Experiments are being made with meters that can be employed in artesian wells to prevent withdrawal of water in excess of amount to which operator is entitled. Drilling of new wells is strictly supervised.—*R. E. Thompson.*

STREAM POLLUTION

A Study of the Pollution of Fish-Containing Waters by Waste Phenolic Waters. S. MISCHONSKIY. 14me Congr. chim. ind., Paris, October 1934, 11 pp. From Chem. Abst., 29: 6680, October 10, 1935. Investigation into harmfulness of phenols in waste coke-plant waters and their biochemically destructive action in natural waters. Potable water rapidly loses its oxygen in presence of sand and earth. This loss is less pronounced in presence of plants; in potable water alone it is negligible. On addition of 10 p.p.m. phenol to water in aquarium containing earth, plants, and fish, there is rapid and very appreciable falling off in oxygen content; presence of phenol would therefore seem to bring into solution certain biochemical catalysts that are but slightly soluble in unphenolated water. Up to 10 p.p.m. phenol can be tolerated by fish, and in presence of earth and aquatic plants it is decomposed at rate of 3 to 5 p.p.m. per 24 hours with accompanying appreciable decrease in oxygen content; in absence of earth and plants both loss of oxygen and decomposition of phenol are appreciably slower (2 p.p.m. per 24 hours). In nature, with much lower ratio of volume to surface than in aquarium, phenomena would occur at much slower rate, with smaller loss of oxygen and less harm to fish life. Conclusion is that, except under very unusual conditions, 10 p.p.m. phenol cannot be cause of extensive fish mortality.—*R. E. Thompson.*

Purification of Waste Waters. F. DIENERT. Usine, 44: 26, 35-7, 1935. From Chem. Abst., 29: 5961, September 10, 1935. Regulations for industrial waste waters as decided on by Conseil Supérieur d'Hygiène stipulate that purified water must not contain more than 30 p.p.m. organic matter in suspension; that, after filtration on paper, quantity of oxygen which is taken up from potassium permanganate in 3 minutes must remain sensibly constant before and after 7 days incubation at 30° in bottle with ground-in stopper, and that water must not give off putrid or ammoniacal odor at end of this period; that water must not contain any substance likely to poison fish and must not be harmful to animals; and that decanted water must not absorb more than 40 p.p.m. oxygen in 5 days at 18°. Regulations are discussed from practical point of view and certain exceptional cases are cited where some latitude will be

permitted in respect both to volume of effluent relatively to river flow and to its composition, for which formula is given.—*R. E. Thompson.*

Further Information on the Harmfulness, with Respect to Fresh-Water Fish, of Certain Hydrocarbons Carried in Industrial Waste Waters. ET. HUBAULT. *Compt. rend. acad. agr. France*, 21: 714-16, 1935; cf. C. A., 29: 4862. From *Chem. Abst.*, 29: 6680, October 10, 1935. Further work shows that benzene it is, that is harmful to white roach, and not thiophene, usually present as impurity. Pure thiophene in quantities tested showed little effect on fish.—*R. E. Thompson.*